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DECEMBER 1946

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SCHOOL SCIENCE AND MATHEMATICS

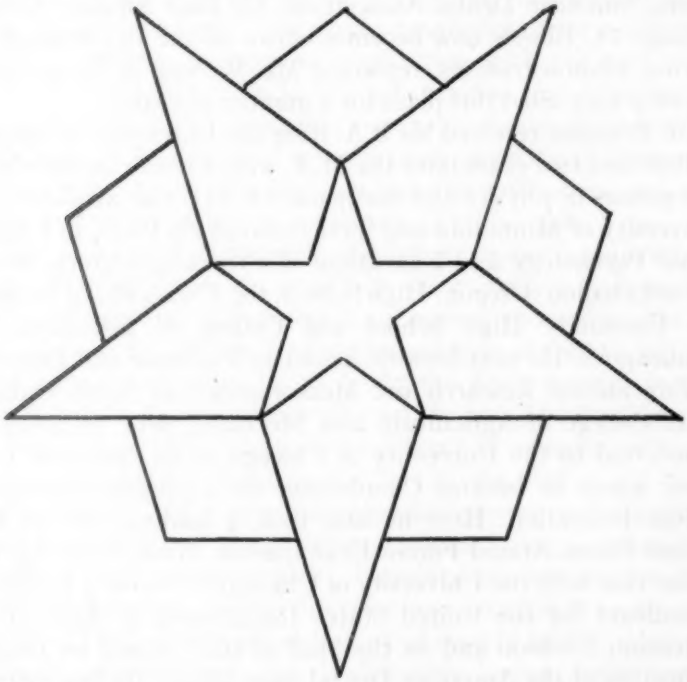
VOL. XLVI DECEMBER, 1946 WHOLE NO. 407

A CRYPTIC CHRISTMAS GREETING*

A. N. TUCKER

J. Sterling Morton High School and Junior College, Cicero, Illinois

2 N 1 T 9 O 4 M 5 E W A I A L C L R T E H O G P O N O E D E



* This greeting was sent us a year ago but did not reach us in time for publication in our December 1945 issue.—Ed.

To crack the code:

Start at the lower inside vertex of the inner star.

Proceed in clockwise direction along broken lines, labelling each intersection with letter or digit as it comes.

Keep to the inside track as long as inner points remain unmarked.

When all letters are placed on the figure, draw five concentric circles. Read the message from the circles, spiraling inward beginning with the largest circle.

THE KEY TO THE CHRISTMAS MESSAGE IS THE STAR

A NEW EDITOR FOR SCIENCE DEMONSTRATIONS

Dr. Schailer A. Peterson, Director of Educational Measurements, American Dental Association, 222 East Superior Street, Chicago 11, Illinois now becomes editor of our Department of Science Demonstrations, replacing Mr. William A. Porter who has very ably filled this place for a number of years.

Dr. Peterson received his B.A. from the University of Oregon in 1930 and two years later the M.A. with a major in chemistry and minors in physics and mathematics. Later he attended the University of Minnesota and there received his Ph.D. in Educational Psychology and Education. His teaching includes work at the Lebanon (Oregon) High School, the University of Oregon, the University High School and College of Education at Minneapolis. He next became Associate Professor and Director of Educational Research and Measurements at South Dakota State College of Agriculture and Mechanic Arts. In 1943 he transferred to the University of Chicago as an Assistant Professor where he became Coordinator for a project evaluating Indian Education. Here he also took a leading part in the United States Armed Forces Examination. While retaining his connection with the University of Chicago he is now a Research Consultant for the United States Department of Agriculture Extension Division and on the Staff of the Council on Dental Education of the American Dental Association. He has written for this journal in the past and has made many contributions to various educational, psychological, radio, and dental journals.

OF MILLIONS AND MILLIONTHS

ELSA H. MUUSS

Chicago City Junior College, Wright Branch

The concept of quantity is a fundamental one, yet it is interesting to note how frequently the psychological limitations of human ability to grasp the idea of number size is overlooked or ignored. The usually alert teacher often passes by an opportunity to help the student gain an adequate knowledge of magnitude, especially in reference to extremely large or very small positive numbers. Yet our civilization demands that we possess an understanding of such numbers. Government expenditures today run into billions of dollars; astronomers are discovering heretofore unknown nebulae at distances far beyond the comprehension of the average man; while on the other hand scientists are splitting the atom and manufacturers are producing machinery which measures correct to ten-thousandths of an inch. We cannot expect our young people to adjust adequately to this dynamic, progressive civilization with the tools which were provided for them in the much more static civilization of our ancestors. It is necessary that some means, mathematical or otherwise, be provided to help them understand the society in which we live, the society in which the entities are no longer measured in units, but in millions and millionths.

The faculty of perceiving number is probably inherent in man. Number sense has even been discovered in birds and insects. Many birds will desert their nests if more than one egg out of four are removed. Experimentation seems to indicate that a crow can count up to 4.[1] In the April issue of SCHOOL SCIENCE AND MATHEMATICS, the article on "The Mathematics of the Honeycomb"[2] shows the existence of some knowledge of engineering mathematics on the part of the bee.

Observation and experimentation with domesticated animals, such as horses and dogs, however, have failed to reveal any faculty of perceiving number. Even apes do not seem to have any number sense. The ability to grasp magnitude seems to be confined to some species of birds and insects and to man. And even in man number sense is definitely limited both psycho-

[1] See Dantzig, Tobias: *Number, The Language of Science*, McMillan, 1933, p. 3.

[2] R. F. Graesser: *The Mathematics of the Honeycomb*, in SCHOOL SCIENCE AND MATHEMATICS, April 1946, p. 339.

logically and sociologically. Psychologically man's faculty to perceive number size both visual and tactile, rarely extends beyond four. Sociologically the civilization in which a man lives may exert a pressure upon him to extend his inherent knowledge of number size and may provide tools which enable him to grasp more easily the meaning of magnitudes. Australian savages can rarely count above two; the Niues of the Southern Pacific still say, "One fruit, two fruits, many fruits." Ask the African Bushman how many wives he has, and if he has more than two he will say, "Many." (or "Too many!" depending upon the situation . . .)

In our civilization, the two tools which we apply to extend our inherent concept of size are measurement and counting. We separate a continuum like a line, area, or volume into essentially equal parts or units, and then count these parts to determine the size of the continuous whole. In order to determine magnitude more adequately we apply the unit best suited to the continuum to be measured. But even this is not enough. In view of the fact that our present society is measuring in terms of millions and millionths, it is not always possible to comprehend the meaning of such quantities. What can we do to extend our limited range of understanding?

Astronomers have sought to remedy the situation in the past by introducing the unit of measurement called the light-year. Perhaps other new units should be introduced to bring these incomprehensive magnitudes within the range of our understanding. But until some budding young mathematician writes his doctor's thesis on this problem, we will have to remedy the situation by mathematical or non-mathematical comparisons which lie definitely within our range of understanding.

How large a number can you understand? Perhaps you were listening to the radio when a news commentator said that the U.N.O. needs 95,000 tons of food to relieve the food shortage in the starving countries of Europe. What did it mean to you? Probably you, as scientists and mathematicians, made comparisons and estimated that this amount of food would fill 4750 box-cars, or 95 train-loads of 50 cars each; or that an equal weight of water would cover a square mile to the depth of approximately 1.3 inches. But to the average person the 95,000 tons of food meant "many" tons, just as the number 3 means "many" to the African Bushman. Had the announcer made an error and said 85,000 tons instead of 95,000 it would probably

have made little difference to the average individual, although the former weight is 10,000 tons or 20,000,000 lbs., or 320,000,000 ounces less than the latter weight; sufficient food to give every man, woman, and child in a large city like Chicago, approximately 5.6 lbs. of groceries!

When you hear that the Federal Government is planning to make a loan of $9,000,000,000 you might make a comparison to gain some conception of the size of this number, but to the average person the sum means "a great deal" of money. To the millionaire it means several thousand times as much as he has and certainly more than he would be willing to pay taxes on! To the pauper it means an "infinitely" large quantity. If we were to move the decimal point one unit to the left, it would still represent an incomprehensible sum to him. His response to the new number would be essentially the same as to the old.

The merits of our number system are familiar to all of us. With only ten different symbols we can express any number howsoever large or small it might be, and can express it with relatively few figures. However for an adequate understanding of number size, especially extremely large or very small numbers, this is not enough. And yet we cannot with a clear conscience allow our boys and girls to grow up and accept without understanding such concepts as the huge sums of money that the government spends for its many enterprises; we cannot allow the new researches in physics and chemistry, which are concerned with extremely small quantities, to pass by without complete appreciation on the part of our new generation. We are living in a world measured in millions and millionths, and we must accustom ourselves to think in terms of these entities.

The educational implications are clear. First of all: let us not forget that arithmetic is a language of size, and let us teach it with this in mind. It is my belief that the child who puts the decimal point in the wrong place does so partly because he can not comprehend the difference in size between the two numbers. The girl who adds $\frac{1}{3}$ to $\frac{1}{2}$ and gets $\frac{2}{5}$ does not have an understanding of magnitude. The boy who cannot remember that there are 1728 cubic inches in a cubic foot cannot mentally see the relationship between the two quantities. But he can be taught. Let us use visual material, such as placing in a one-foot cubic box, a number of one-inch cubes. Let him see that there will be 144 in each layer and consequently 1728 in the twelve layers. Let us use tests which require the arrangement of numbers accord-

ing to size, and let us stress the practice of approximating answers.

Secondly, the child should and can be taught to estimate magnitudes. Psychologically his ability to do this is limited, but he can be trained to extend his inherent knowledge. It should be understood, however, that the problem is a complex one. In teaching the student to estimate a length, for example, it is necessary to realize that a vertical distance, such as the height of a tree, presents quite a different problem psychologically from that of estimating a horizontal distance, or finding the dimension of a depth along the line of sight or along other lines of view which radiate from the eyepoints. In teaching a student to estimate an area, it must be realized that each plane figure presents a problem peculiarly its own. Moreover, the position of the plane in space must be considered. The fact that a student can estimate with an acceptable degree of accuracy the area of a plot of ground, does not guarantee his ability to estimate the surface area of a silo, for example. We are faced here with several different kinds of problems.

Familiarity with the quantity to be measured is an important factor in the estimation of size. We may be able to estimate within an error of one or two percent the number of people in a group of 250 persons, while it may be impossible for us to come within twenty percent of the number of beans in a jar containing 250 beans. A rancher can, at a single glance, give a better approximation of the number of cows in a herd than can his more sophisticated city brother, but the latter can probably tell with a greater degree of accuracy the measurement of a chorus girl's waistline than can the former! In estimating number size, we must realize that the student's familiarity with the object under consideration will effect his ability to measure it, and that psychologically different objects present different problems.

Thirdly: to bring extremely large or very small numbers within the realm of a student's understanding and experience, let us use comparisons. We can show, for example, that if the proposed government loan of $9,000,000,000 is to be repaid at the rate of $100 per minute, it would take 170 years to repay it. The Gage-maker works to an accuracy of one ten-thousandth of an inch. We can point out that if a sheet of paper could be made as thin as that, it would take 30 sheets laid one on top of the other to equal the thickness of an ordinary sheet of news-

paper. One ten-thousandth of an inch is to one inch as the thickness of a human hair is to 30 inches. One ten-thousandth of an inch is to one inch as $6\frac{1}{4}$ inches are to one mile.

It is true that we cannot expect the students to carry with them the information and instruments by which they can make comparisons, but if we teach the students to think in terms of ratio and proportion as a method of making comparisons, if we stress the importance of thoroughly understanding the meaning of extremely large or small numbers, if we get the student in the habit of thinking in terms of millions and millionths, we have certainly given him a clearer understanding of the universe and civilization in which he lives.

1947 NATIONAL TEACHER EXAMINATIONS AVAILABLE TO SCHOOL SYSTEMS AND TO COLLEGES

The American Council on Education has announced the eighth annual administration of its National Teacher Examinations. These tests will be administered in official examining centers throughout the United States on February 8 and February 15 in 1947.

Arrangements are now being made for the establishment of examining centers in connection with school systems and collegiate institutions engaged in teacher education.

The National Teacher Examinations were made available by the American Council on Education as an aid to administrators in their efforts to improve the selection of teachers. The tests included in the battery are designed to provide objective measurement of certain of the abilities and knowledges of prospective teachers. They measure the intellectual, academic, and cultural backgrounds of prospective teachers, and are used in combination with records of experience, academic marks, ratings in various aspects of personality, etc. in the evaluation of an individual's qualifications for teaching.

Superintendents and Boards of Education in many localities require teaching applicants to present National Teacher Examination records. The examinations are also used in colleges as qualifying examinations and as guidance instruments to provide additional bases for student self-study of individual strengths and weaknesses in areas measured by tests.

The sponsors of the program emphasize the fact that misuse of the examination results as a sole basis for teacher selection is opposed. Records of experience, academic marks, ratings of various aspects of personality, etc. should be considered in addition to the National Teacher Examination record in the evaluation of a prospective teacher's competency.

Used in combination with additional information of the types named, it is believed that the National Teacher Examination results can contribute materially to the attainment of education's fundamental goal, the provision of the best possible instruction for young people in the schools.

Arrangements for cooperation in the Teacher Examination project may be made by writing to Dr. David G. Ryans, Associate Director, National Committee on Teacher Examinations, American Council on Education, 15 Amsterdam Avenue, New York 23, New York.

IMPROVING LANGUAGE ABILITY IN MATHEMATICS

WHAT APPROACH SHOULD BE USED TO IMPROVE THE PUPIL'S ABILITY TO TRANSLATE THE PRINTED WORD INTO THE SYMBOLIC LANGUAGE OF MATHEMATICS?*

DORA E. KEARNEY

1105 W. 23rd Street, Cedar Falls, Iowa

The topic originally assigned to me was, "What approach should be used to improve the pupil's ability to translate the printed word into the symbolic language of mathematics?" That is the topic which I have considered. However, I have changed the word "should" to "could" since I do not presume to dictate the *one* best approach. Anyway, there probably is not *one* approach that would suffice for *all* classes or *all* pupils. I shall merely give an example of one possible approach.

Before proceeding with the example I will say that probably every approach should be based upon the premise that it is essential that the symbols have meaning to the pupils.

In translating word statements into the symbolic language of mathematics it is often necessary to write an indicated division as a fraction. Laying a foundation upon which to develop this ability would include teaching the division meaning of a fraction.

The teacher could open the class by telling the following story. "Four boys bought three apples of the same size. The boys wanted to divide the three apples so that each would have the same amount. How much would each boy have?"

If the teacher tells the story some one will probably be able to give the correct answer. After the answer has been given the teacher will write "$\frac{3}{4}$" on the board. Then she will ask to see the hands of those who have questions. Hands, pupil remarks or facial expression will probably indicate some difficulty. If this is so the teacher will sketch three apples on the board. Then she will say, "What would be the easiest way to divide three apples among four boys?" Some one may give a good answer to her question. If so, she will illustrate the answer given. If not, she will say, "We could divide one apple among four boys. How could we do that?" Some one may be able to reply correctly. If

* A paper read during the mathematics panel discussion at the meeting of the Junior High School Group of the Central Association of Science and Mathematics Teachers at Chicago, November 23, 1945.

so, she will illustrate the answer. If not, she will say, "Couldn't we cut the apple into four equal pieces and give each boy one of them?" As the teacher finishes she draws the four quarters on another part of the board. Then she says, "How much of the apple will each boy get?" If the answer given is "$\frac{1}{4}$" she goes on from there, if it is "a quarter" she says "Or, $\frac{1}{4}$." Then she says "What could the boys do next?" After the answer is given the teacher illustrates it on the board. Then she says, "How much would each boy get?" "When the boys were through dividing all three applies how much would each boy have?" "Are there any questions now?"

Then the teacher will go back to the board where she has written "$\frac{3}{4}$" and will point to "$\frac{3}{4}$." As she does so she will say, "The line in a fraction means 'divided by.' This fraction means '3 divided by 4.'" "Are there any questions?"

Then the teacher will say, "I wonder if there are any of you who could come to the board, tell a story such as the one I made up, write the correct fraction on the board, tell what the line in a fraction means and then tell us what the fraction means. Could you do those four things?"

There will probably be a number of interested people who want to try. If no one feels ready to do so, or if those who try do not succeed, the teacher will say, "I will do another one for you." Then she will tell another story, write the fraction on the board at the end of the story, and give the two explanations thus.

She will say, "Five girls had two sticks of candy of the same size. They wanted to divide them equally between the five girls. Each girl would have $\frac{2}{5}$ of one stick." The teacher will then write the fraction $\frac{2}{5}$ on the board. Then she will point to it and say, "The line in the fraction means 'divided by.' This fraction means '2 divided by 5.'"

Notice that this time there is continuity in the story and illustration. This time the teacher does not stop to question the class, but gives the recitation as she would expect a pupil to do. But she is alert to catch any sign of inability to understand, and reverts to her former procedure if further explanation is necessary. When through she says, "Let me see the hands of those who could now make up a story, write the fraction, tell what the line in the fraction means and tell what the fraction means. Can you keep all four of those things in mind and do them all?"

She will probably get good pupil performance this time. If not, she will repeat the above procedure until she does.

Let the first pupil who succeeds go to the back of the room to work on similar material. The teacher can say, "Get a sheet of directions from the desk, go to the back of the room and follow the directions." The directions will be similar to the following.

1. If 3 apples of the same size are divided equally among 4 boys each boy will get $\frac{3}{4}$ of an apple.

The line in a fraction means 'divided by.' This fraction means 3 divided by 4.

2. Make up other examples like that in 1 above. Write them out completely just as 1 is written out. Put them on a new sheet of paper. Head the paper, *One meaning of a fraction*. Number each example. Do your work so well and so neatly that we can put your paper on the bulletin board and give it to other pupils to study."

The above procedure was used in the poorer section of the poorest eighth grade I have ever had. The pupils were enthusiastic. They were anxious to try and try again. Each pupil who succeeded at the board went to the back of the room. All were back there before the fifty-five minute period was two-thirds over. There were sixteen pupils in the class.

I have the original papers written by these sixteen pupils. The following selections are from three of the papers.

"If 12 cookies are divided equally among three boys each boy will get 12/3 of the cookies. The line in a fraction means 'divided by.' This fraction means 12 divided by 3."

"Five boys went out camping. They had 3 oranges of the same size and wanted to divide them. Each boy got $\frac{3}{5}$ of an orange. The line in a fraction means 'divided by.' This fraction means 3 divided by 5."

"There were 8 boys going on a hike and they had 16 sandwiches and they wanted to divide the sandwiches among themselves. Each boy got 16/8 of the sandwiches. The line in a fraction means 'divided by.' This fraction means 16 divided by 8."

A seeing-eye for blind men is a nine-pound case the size of a loaf of bread that is carried in one hand. A beam of light projected from the case is reflected by an object ahead picked up and converted by a photocell into code signals in the blind user's earphone.

PSYCHOLOGICAL STANDARDS IN MEASURING ACHIEVEMENT

MAURICE H. KROUT

Chicago City Junior Colleges, Wilson Branch

The objectives of any type of planned influence of one individual on another can be most conveniently stated in terms of attitudes. But attitudes must be understood to mean tendencies preparatory to action or, to put it differently, implicit motor responses which can receive expression in actual social situations. As such, however, they need some clarification.

Psychology is vitally concerned with techniques of developing attitudes. It is concerned with both preventive attitudes leading to inhibitory or negative behavior and with positive attitudes leading to permissive or positive behavior. Both, of course, are necessary in different situations to insure intelligent adjustments in the free citizens of our republic. The contributions of psychology along this line have been diligently exploited in texts and courses in the field of educational psychology, and their helpfulness has been rather widely recognized. Because, however, there is a tendency now to divorce psychology from education, instead of looking at education as an applied form of psychology, it may be worth pointing out anew how psychological theory applies to educational procedures, especially in testing and grading student achievement on school and college levels.

To begin with, we must recognize that attitudes, whether they are built up rapidly or slowly, do not come into existence full-blown or spontaneously. It is for this reason that the process of education has been regarded as synonymous with achievement. It is such only because it involves three stages of development through which, whether our courses are shaped to recognize them or not, students must pass. These stages are: 1) perception-cognition, 2) concept-formation, judgment, reasoning, and 3) fixation of motor sets capable of release in suitable situations. The last of these, of course, is the stage of attitude formation. But the stages preceding it cannot be disregarded.

Every student first becomes conditioned perceptually to given verbal signs, i e., terms and their meanings (definitions). In learning to perceive certain terms, students learn to recognize them as well. They thus acquire what Herbart long ago called an apperceptive mass, a store of basic tools which may or may not be later utilized in concrete situations. This primary stage

in learning, it must be repeated, is wholly verbal. It is the stage in which responses to symbolic signs constitute an end in themselves as it were.

The stage of concept-formation is the stage in which the relation of verbal signs to other signs is mastered by the student, under the instructor's influence, not because the student is consciously motivated to do so, but because the process of learning leads to it as a logical second step. In this stage, the discrimination between one term and another, and between terms and concrete facts, is acquired. If the end-product of the first stage, insofar as it is successful, may be said to be the acquisition of a meaningful vocabulary (i.e., knowledge *of* facts), the end-product of this stage may be described as the achievement of intelligible (verbalizable) opinions or judgments *about* facts.

The formation of attitudes is ultimately attained when, and only when, the student acquires abilities to react to life-*like* situations. A life-like situation would be preparing soap in a course in organic chemistry; inter-breeding animals after a course in genetics; voting at the polls in a college election, not to say an actual political election, after a course in political science; and joining or even organizing an interracial club at college, after a course in sociology. Since life-situations are not conceivable as part of classroom procedure, we must think substitutively in terms of classroom situations. These might be laboratory tests, in the physical and biological sciences (including psychology), or descriptive problem-situations in the social sciences which are obviously more handicapped than any of the older sciences. The important thing is attitude-formation as an end-result of courses in which the psychological aspects of education are recognized and properly implemented.

All this is neither new nor enlightening. It is brought up here for purposes of completeness in presenting the arguments below, which concern our testing and grading procedures.

Now, obviously, if the three stages of learning are separable, especially because their attainment in each student's case is neither universal nor common, we must recognize that testing techniques should be, and are, also separable. Thus, to test perceptual (meaningful) responses to verbal signs (terminology), we employ simple-recall, true-false, and completion techniques. These are forms of controlled word-association, which help us diagnose the student's naming or identification skills. To test concept-formation, inferential reasoning, and the development

of discriminating judgments, we use multiple choice (single response) and matching techniques. To test abilities to apply concepts or reasoned judgments to concrete situations, we resort to laboratory tests, essay tests or, possibly, plural-response multiple-choice tests, if so arranged as to constitute life-like problems.

Those who have been interested in the hypothesis of maturation and "insightful-response" theories, recently contributed by the organismic school of psychology, point to certain flaws in the stages genetically involved in the process of learning. They maintain that some individuals make remarkable progress in learning situations by advancing boldly from the verbal-sign stage to the stage of ability-formation. They also point out that, in some cases, neither the first nor the second stage can be discovered as such. Granting these possibilities in certain instances, no one can deny that some individuals do not advance beyond the first or second stage, regardless of how they come by the achievement of those stages. While insisting then that the three stages are those involved in normal progress, yet we cannot deny that deviations do exist. Whether they are so common as to be considered normal is certainly questionable. It is more likely that they are not.

We might call learning in which the first or the second stage, or both stages, are not actually achieved, *fractional* learning. Any other term might serve our purpose, but this will do to bring out the implications of the present argument. In terms of testing, we have here a situation parallel to that of a typical schizophrenic reaction on a Stanford-Binet or some other test standardized in terms of mental age. The schizophrenic, as is well known, gives characteristically a scatteration of responses, where some questions on higher age-levels are correctly answered, but much simpler responses on lower levels are missed. A schizophrenic's intelligence test may yield a relatively high I.Q. for that reason; but as a test of abilities it fails completely, in that it fails to show *consistent* abilities not merely because it shows failure on simpler levels but because it throws doubt on the abilities displayed on higher levels as well.

Fractional learning in students who do not show consistent achievement on each of the levels indicated is not necessarily abnormal, but it does lead to an educational end-product which is worth distinguishing, in terms of grades, from achievement in which the goal-attitudes of a given course have been attained. The possibilities of deviate learning may thus be narrowed down

to cases in which 1) only perceptual familiarity with terms has been achieved fully or relatively fully (say to the extent of 75%) 2) perceptual familiarity as well as discriminating judgments, on a verbal level, have been established or relatively established, 3) perceptual familiarity with terms and the ability to implement discriminatory knowledge has been achieved, but no satisfactory (75% or better) evidence is obtained of the achievement of verbal discrimination or reasoning, 4) discriminatory judgment has been established and actual abilities (in terms of goal-attitudes) have been demonstrated but no satisfactory evidence of perceptual responsiveness (as shown in definitions of terms) can be obtained and, finally, 5) perceptual, conceptual, and attitudinal responses can be obtained to a sufficient degree to prove the functional maturity of the learner.

These are not idle distinctions. To the writer, they imply the possibility of three different types of testing, using techniques previously indicated for each of the stages; and they mean likewise grading on the basis of the five possible types of achievement previously listed. It is suggested that achievement of type (2) be graded *C*, achievement of types (3) or (4) be graded *B*, and finally that achievement of type (5) be the only one recognized as of *A* caliber.

This three-level testing procedure seems to possess certain shortcomings. In the first place, it is difficult to say when or where in a given course the first stage of learning ends and the second or the third begins. In the second place, as most courses are now organized, there is no attempt made to differentiate the three aspects of learning in the course of instruction. So long as this is the case, we cannot expect our students to give evidence of achievement on the three-stage basis. Attempts to measure achievement must go hand in hand with attempts to make the types of achievement sought for possible. Nevertheless, the three-level plan suggested gives a logical and workable scheme of differentiating levels of achievement, and grading on a more objective basis. I suspect that this type of grading will correlate more highly with I.Q. than past records of scholastic aptitude have been likely to correlate. I suspect also that it will correlate more highly with actual achievement in after-school years. What is most important, however, three-level testing will give teachers a framework in terms of which to plan their course objectives and by which to gauge the extent to which their objectives are actually being attained.

REMEDIAL INSTRUCTION IN CHEMISTRY

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Up to the year 1930 little or no attention was given to the remedial phase of instruction in high school chemistry especially for the so-called non-college pupils. The great majority of the personnel of this type of course is composed of the low ability groupings, and it became a problem worthy of investigation to ascertain many of the difficulties both from the staff and from the pupils themselves. With the information thus gained, definite remedial treatments were applied. The content of this article is to enumerate some of our findings and the corresponding treatments pursued.

First of all, something of the history of the secondary school ought to be brought out in order to acquaint us with the origin of our problem. Since 1890 each succeeding decade has witnessed a doubling of high school enrollments everywhere. Today nearly three-fourths of the youth of high school age in the nation as a whole are actually enrolled. In New Jersey secondary school attendance reaches 90% (1). One of the prominent results of this influx was the taxing of what programs of remedial work as existed, thus rendering them inadequate (2). The stark fact that even today there exists no well-directed or simple plan to cope with this problem of the educationally neglected pupil constitutes an acute challenge of the public secondary school (3). Further, from a study involving selected schools over the nation, it has been established that there is a steady trend toward the lowering of the mental and the chronological ages of pupils on the lower scale of mental maturity, and toward the lowering of the mean IQ of high school pupils as well as an increase of those remaining to be graduated (4). Therefore, this huge enrollment increase included low ability persons, as well as high and average ability groups, a fact we must not lose sight of.

Two outstanding factors in maladjustment seem to be lack of interest and verbal ability (3). We began our work with this postulate as gleaned from the reference noted as reliable. At present, about 75% of the credits available for high school progress are in the core subjects (5). Thus, the non-college pupil starts upon a high school career with a three to one handicap. Too many high ability pupils are achieving only mediocre suc-

cess as well, so that they too can be said to be educationally neglected. However, more low IQ cases leave school before graduation than high or average, since the mean IQ rises consistently from grade 9 through to grade 12. In other words, the more incapable a pupil seems to be, the sooner he is released to face the problems of life, and so as school people we fail in this particular unless we make some kind of provision for this situation (6). When remedial measures are neglected by our schools, the jails take over. In an interesting study by Dr. Counts, a list of factors that determine why pupils leave school includes lack of interest, failure, and low intelligence (7). For every low IQ case who leaves school, one remains (8). This, I feel, is an indictment of the remedial set-ups in our public institutions of learning. Back in 1924, Dr. Powers told us that a considerable proportion of high school chemistry was of little or no value for many who elected it (9).

In other words, these pupils about whom our program needs to be directed are excellently described by Burt (10) as those who fall in the 75–90 IQ range, and who compose 15% to 20% of the school population of the average community, the group just below the middle 50%–60% and just above the lowest 5%. Remember that these pupils vary in *degree*, not in type from the characteristics of the entire group and unless we recognize that *functional* learning in skills, knowledge, and training must occur, we fail.

The next question is how to locate these neglected pupils. In a way, it is true that there is no sure statistical means to find these people, and to classify them, simply because maladjustment is not the result of one factor, but the product of many. However the means at our disposal are sufficiently informative as to suggest trends and tendencies, and thus cannot be said to be altogether unsatisfactory. Inasmuch as our intelligence tests require abstract and verbal ability they mean but little when it comes to the interpretation of the status of non-academic pupils (12). Then too, statistics do not show the large number of pupils who, while passing, fail to profit (13, 4). The inevitable result is a lowering of standards, which practice doesn't correct anything, and is unfair to pupils at both ends of the scales of rating.

From the above considerations, I would like to recommend a feasible procedure. Diagnostic tests in intelligence are administered to pupils suspected of needing remedial aid and those

making 70 to 90 scores constitute a starting point. Vocabulary test scores from 8% to 25% need treatment, as well as reading test scores under 50. With these results, we list pupils passed with reservations, their backgrounds, weaknesses and strengths, and check this against teachers' judgments. Now we have our group selected. This is a fascinating problem in supervision, and much further aid can be had by consulting Breuckner and Melby (11), and also Hildreth (14).

Finally, I would like to offer the following practical scheme of identifying and treating some of the difficulties in high school chemistry as has come to our attention in this work and in our experience:

Difficulty	How observed	Remedial measure	Example
Locating purpose of experiment, or gist of a paragraph	By responses that are incomplete, incorrect, irrelevant	Pupils write object of exercises. Use assignment sheet of pointed questions for homework	"Oxygen burns" instead of "Oxygen supports burning."
Failure to decide upon the *kind* of effort needed to arrive at best solution of activity	Hunting through book for *an* answer, instead of *the* answer	Teacher solves a few situations before pupils engage in activity	In working of the fire-extinguisher, point out factors of combustion and one has to be removed
Failure to connect experiment drawings, with the unit of study	Frames inadequate responses or gives up	Show pupil he failed to use all helps available and made it hard for himself	His developing of a print was begun by light and stopped by hypo fixer
Does not rationalize materials and sees no need for it	He memorizes and dreams while he reads. Lip motion often evident here	Give questions that call for reflective thinking. Make outlines and charts in advance	Show how to distinguish between distilled and tap water
Lacks ability to draw conclusions from *all* the evidence	Pupils speak before thinking	Impress on him that first thoughts often erratic, since thinking requires time	Cu ions blue because if SO_4 ions were, then H_2SO_4 would not be colorless
Hard to locate major and minor points.	Unable to see reason in sequences and purpose of assignments	Give clear previews, repeating objectives, and show pupil signpost paragraphs and topic sentences	Oxide ores reduced to get the metals. Sulfide and carbonate ores, by first oxidizing them, are also reduced

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FREEDOM TO LISTEN URGED FOR WORLD UNITY

Freedom to listen must be added to freedom of speech and the freedom of the press if the people of all the world are to live in an understanding of each other, David Sarnoff, president of the Radio Corporation of America, told the Princeton University bicentennial conference.

He suggested that the United Nations erect, maintain and operate an effective world-wide system of broadcasting that can reach all the people of the world freely and simultaneously. In addition to broadcasting the public proceedings of the United Nations in all principal languages, the system should be open to other broadcasters and the press.

People everywhere must be able to listen without restriction or fear, he stated, referring to radio communications. War revealed in a spectacular way the vital significance of communications. In a world struggling for rehabilitation from the ravages of war there is no doubt that communications represent an important factor in human affairs and in any formula for peace.

Gen. Sarnoff advocated also that the United States develop an adequate national plan for international broadcasting. Other nations, England particularly, have such broadcasts. This "Voice of America," he said, should be supported by the Government and private industry in cooperation.

LABORATORY FROGS HAVE DISEASE LIKE LEPROSY

Frogs develop a disease resembling human leprosy when kept in aquaria, Dr. S. Meryl Rose, of the Smith College zoology faculty, reports in *Science*. First symptoms are persistent sores on the toes and red spots on the legs. As the disease progresses, the flesh begins to fall away, and sometimes entire feet are lost. Nervous function is seriously impaired.

The disease can be prevented, Dr. Rose states, by keeping the frogs in water containing fifteen hundredths of one per cent of salt.

WHY NOT COURSES ON RECENT DEVELOPMENTS IN SCIENCE?

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Insofar as the writers have been able to ascertain, not a single graduate school in the United States offers coursework in recent developments in science designed to keep the secondary school science teacher up to date on recent happenings in science and thus to help him discharge his teaching responsibilities more effectively. This article advances the thesis that courses of this type are much needed and that they would fill a highly useful purpose in secondary school science education in our nation.

Nothing gives a science teacher more confidence than to know his stuff in the latest developments in science, particularly in his own area of specialty. This confidence reflects in more dynamic teaching and in vastly increased interest on the part of the learner. Knowledge of what is going on in science, especially on the part of the instructor, sets the stage for lively, meaningful class sessions. To know the things which are not yet in the textbooks makes for vital activity. Knowing the last word in science is one of the best weapons a teacher has to promote aggressive science learning. The counterpart of this is that such knowledge is one of the best forms of insurance against static classes and lackadaisical students.

But the problem goes beyond mere interest in the science classroom. There are more subtle ramifications. In the nation at present there exists an acute shortage of competent scientists, thereby placing upon the country a handicap it can ill afford to bear. During the war both basic research and the education of scientists practically came to a standstill. Existing scientific knowledge was and is still being exploited for practical application to military problems, and we have inevitably fallen far behind in our scientific work. These are some of the reasons why the demand for scientists has come to be at least twice what it was before the war.

College and university enrollment is at an all-time high during this academic year of 1946–1947. Administrators have had extreme difficulty in locating competent teachers in engineering

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and the physical and biological sciences. There can be little doubt that sub-standard instructors have been employed in more than a few cases simply because top quality teachers were not available.

Industry is undertaking programs of scientific research on an unprecedented scale. Through experience, they have learned that expenditures on such programs pay excellent returns. Yet their programs are being cramped at their inception because of the disconcerting shortage of scientific personnel.

Finally, thousands of well-trained scientists are needed by government agencies, especially by the War and Navy Departments. Urgent scientific research of national importance is being held up by the lack of competent scientists to do the work. It is agreed that work in a wide variety of areas—atomic power, bacteriological warfare, rockets and guided missiles to name a few—must be advanced without delay if the nation's position is to be secure. Here again the lack of scientists to advance this vital work is alarming.

This problem of scientific personnel shortage cannot be solved overnight. As Secretary of War Patterson has said: "There is no four-lane highway to scientific achievement. A bulldozer is needed every inch of the way." The shortage will probably continue at least five to ten years, long enough for a new crop of scientists to be graduated from our colleges and universities.

America's institutions of higher education will have to take the initiative and assume the major share of responsibility in relieving this shortage of scientists and then maintaining a high quality supply for the country. Industry and the government, however, must also carry their share of this responsibility. These agencies are beginning to recognize their obligations as well as their opportunities and are arranging for in-service training programs in science and for various types of cooperative programs with colleges and universities.

But all of this is not enough. Secondary schools can render invaluable service through the early detection of scientific talent and through early instruction in science which makes sure that the youthful scientist gets off on the right scientific leg. Basic scientific training cannot begin too early, and the higher the quality of instruction, the better. That is where the course for teachers on "Recent Developments in Science" comes in. Where could one find better ammunition for building the intellectual fires of a young scientist than to bring him into

contact with an up-to-the-minute instructor who knows his stuff regarding the latest scientific discoveries?

The course we have in mind should be aimed specifically at teachers of secondary school science—junior high school through junior college. It should cut across the conventional fields of science subject matter and deal with all fields of science. Primary emphasis should be given to qualitative rather than quantitative considerations. Because of its general nature, it is suggested that the course not be given in the department of any particular science. Perhaps its best repository would be in the Department of Education, for after all it is a course in Science Education. The course should carry graduate credit but should also be open to advanced undergraduates ready to embark upon a teaching career in secondary school science.

Perhaps the course would serve the greatest number of science teachers if offered in the summer session. A concentrated two or three weeks' course offered between regularly scheduled sessions should also prove effective. It would have the advantage of being short—somewhat like a football coaching school—and would cater to science teachers willing to spend a few weeks in such an activity but not willing to attend a full summer session. A short inter-session course of this type would afford maximum opportunity for field work. These suggestions do not, it is understood, preclude offering the course during the regular academic year.

It is important that not only the recent developments in science be discussed in this course—although that is admittedly a very important part of the course, but also that the social implications of these developments be emphasized. These recent developments are doing something *to* society as well as something *for* society, and the instructor we wish to see in our secondary school goes beyond the facts of science to interpret their social significance in the context of the whole of human relations —at least as far as he, the science teacher, sees it.

Some reader will argue that such a course as herein advocated is not necessary, that the up-and-coming science teacher will keep up-to-date without academic assistance, that being a professional man, it behooves him as one of his first requirements in his profession to keep informed. These are lovely sentiments, but they are not valid arguments. Science moves so fast these days that the scientific specialist cannot keep up completely even in his own field, much less a secondary school

teacher who must have a wider field of interest in more general areas. There is no point in telling this latter individual to lift himself by his bootstraps, to dig out all this recent information from newspapers, professional periodicals, magazines and textbooks. What with a full teaching load, coaching or some other co-curricular activity, participation in the life of the community of which he is a part, professional reading in education as well as science, and some time for his home and family, there is not much time left for digging textual material out of assorted references on an individual research basis. He needs help. That is where the course in recent developments in science comes in.

A few readers will argue that such a course is not necessary for another reason. They will say the principles of science are the same now as they were when the instructors were in school and that when all is said and done it is these principles of science which count. Well, that is partially true. The laws of Galileo, Faraday and Newton are still essentially correct and useful, and we do not want them passed over lightly. But they are not enough. The vibrant and thrilling developments of modern science must be brought into proper focus, both scientifically and socially, if science instruction is to fulfill its purpose in modern society.

A few years ago, Benjamin wrote a book called *The Saber-Tooth Curriculum*. It contends that our scholastic curriculum is impractical and all out of kilter. Antiquated skills, techniques and information, long since obsolete and outdated, still occupy a large proportion of school time in a world which is moving so rapidly that even those who try most diligently to keep up are sometimes incapable of even hanging on.

We maintain that the science teacher who completed his scientific academic work ten years ago—or even five—and who has done no learning in the realm of science since that time is doing his teaching in the context of a scientific curriculum which is, relatively speaking, suitable for students living in the age of saber-tooth tigers.

Put it this way. Suppose a secondary school science teacher "completed" (?) his scientific training in—say—1940 and that he has done nothing beyond casual newspaper and magazine reading to keep up since. At that time he was vaguely aware that chemical laboratories were "playing around" with synthetic rubber, chiefly to see whether it could be made. Even chemists knew nothing of neptunium or plutonium, for they had

not made an appearance. Plastics were coming in but were not well established. Cyclotrons were interesting gadgets with which college physics professors tinkered, but why smash atoms anyway? Betatrons and synchrotrons did not exist. Insects continued to inhabit our homes more or less at will for DDT was only another of those indexed organic compounds with no known practical use. Farmers were still arguing whether hybrid corn was worth the greater cost of the seed. Nobody thought much about bacteriological warfare. Many thought the United States could live alone, that what went on in the rest of the world did not concern us. If war SHOULD come there would be some concern about the quinine supply. We did not have too much. Quinine has not been synthesized, and SN7618, or chloroquine, was not yet known. Penicillium was a rather interesting but definitely objectionable fungus which sometimes got started on our food causing it to decay. No one save a few white-coated biologists had ever heard of streptomycin. Rockets and jet propulsion belonged to Buck Rogers and a few organized crackpots who called themselves The Rocket Society of America. RDX, proximity fuses and radar? Never heard of them! Atomic energy? Oh, yes! That was interesting stuff to contemplate and to do mental gymnastics upon. Theoretical physicists reported that their mathematics showed there was enough energy in the atoms in a spoonful of water to drive the "Queen Mary" across the Atlantic Ocean—or something! But everybody knew mere man would never be able to release enough of that energy to be of any practical value—much less control it if it ever were released in quantity. Some even said that the release of such quantities of energy—if it ever should come to pass—might set up a chain reaction in all forms of matter and blow the whole earth to smithereens. But no worry! Those were only the nightmares of bleary-eyed visionaries.

Well, those vague concepts are illustrative of the position in which many secondary school science teachers found themselves in 1940. If we leave the recent developments out of our science teaching in 1946–47 and thereafter we are indeed teaching in the era of saber-tooth tigers although our students are living in a fast-moving scientific age and one in which still more stupendous things are to come.

During the war the world saw the awful purposes of destruction to which science can be applied in time of emergency. It is not quite so easy to demonstrate dramatically the constructive

purposes to which science can be put. The average layman does not yet appreciate the tremendous industrial and social uses to which war-born discoveries such as radar, atomic power, loran, antibiotics and the like can be applied. Once developed along the lines of peacetime research these scientific discoveries have the possibility of bringing the world to a state of health, comfort and physical prosperity such as it has never known. Ability on the part of the science teacher to point out these possibilities should be an outcome of the course on recent developments in science.

The course we have in mind goes beyond newspaper and popular magazine reports concerning scientific achievements. At the graduate level it discusses scientific principles, basic laws, technical applications, social significance, and if possible provides first-hand manipulation, or vicarious experience via visual aids. Field trips to observe new scientific gadgets in operation will be a part of the course. In other words, it will be as practical as possible. The carry over from the graduate classroom to the secondary school science classroom, modified of course to the level of immature minds, should be great.

Perhaps it would be well to give the course in two sections: one dealing with developments in the area of physical science, the other in the field of biological science. Each should be a complete course in itself. Each section should carry two to three semester hours of graduate credit, and the two could be given concurrently, each course requiring separate registration. The content of the course would be ever-changing. New material would constantly be added and "old" deleted. Over a period of six to eight years the content of the course would be 100% changed. It follows then that every six to eight years the secondary school science teacher would be eligible to re-enroll in the same course for additional credit. Such a policy would be consistent with the initial objective of the course—to wit: to keep the secondary school science instructor informed on the latest developments in science.

"Fine!" you say, "All this is splendid. Now who gives the course? After all, college professors have their work filled out too." Very true. There will be difficulties in finding instructors to give the course. But the fact that difficulties are to be encountered does not justify neglecting the responsibility. The service to be performed is too great.

There are a number of possible solutions to the problem of

instructors for the course. A college staff member who has been given time in his teaching assignment for reading, travel and research may be assigned the responsibility of conducting the course and carrying the major burden of the actual instruction. Preparation would be continuous. He would be given time for professional reading. Travel to and study in the laboratories of other universities, industrial firms and governmental agencies where pertinent research is going on would be an important part of his preparation. Finally, it would be preferable for the instructor to be carrying on some significant research on his own although this is not a hard and fast requirement. Above all he must know his way around and must have kept up to date on the researches in a wide field of the sciences.

Another alternative might be the hiring of a scientist from a research laboratory, possibly on a part-time basis, specifically to teach such a course. Great care should be exercised in the selection of such an individual to make sure he is versed in a wide variety of significant researches, that he is not too technical for secondary school science teachers, that he has teaching ability, and that he has a vital concern for the social significance of scientific developments. Such individuals would probably be difficult to find, but they do exist.

Still another alternative lies in the possibility of conducting the course on a seminar basis. Several specialists from various departments within the university, or from other universities, or from industrial laboratories or governmental agencies—any place where competent research scientists may be procured—would offer sections of the course varying in length from one day to possibly several weeks. A university staff member would arrange for the speakers, coordinate the program and act as chairman of the seminars.

Regardless of how the instruction problem is handled one faculty member from the university must be in charge. It will be his responsibility to organize the course, to pull it into one unit of instruction, to carry through on it, to arrange for room and equipment, to contact special speakers if this is felt desirable, to arrange field trips, to check attendance, and to evaluate the work of the students.

Some inconveniences are likely to be encountered in setting up such a course as recommended herein, but they are not unsurmountable. The rewards should be great. To the writer's way of thinking a course of this type would be extremely valuable.

G.I. VETERAN PHYSICS CLASSES IN HIGH SCHOOL

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The conventional method of teaching high school physics assumes that all members of a class will progress at approximately the same rate. This means that the subject matter can be presented to a class in an orderly arrangement.

In handling more than one class in the subject, the same subject matter can be presented to each group. The exception to this appears when classes are organized on the basis of I.Q., aptitude, ability, or when *enrollments are periodical.*

Early in 1946, Superintendent Caldwell instituted classes in all of the academic subjects for which there was sufficient demand from the returning service man. Among the courses needed was physics, which was expected, due to the importance given to the subject during the war period.

It was found necessary to change the method and contents of the course for several reasons. The fact that men were returning at given intervals throughout the school year and vacation made a complicated situation. They were entering courses which had been in progress for weeks and sometimes months. It became necessary to reduce the content of the course to only the subject matter which fitted the individual needs. It was found advantageous to divide the course into nineteen units, a sample of which is shown in Chart I. Each unit consisted of a reading assignment in the text including one or two chapters, one or more exercises in the workbook, several typical problems, one or more laboratory experiments, and a unit test. The reading assignment, exercises, and problems could be worked outside of class as homework. The experiments and tests must be worked during the time when classes were in session under the supervision of the instructor. All of the grading and correcting of written work was done in presence of the student. At this time, all conflicting views and ideas could be discussed. The writer found this particular partnership work very enlightening. A progressive achievement record, such as is shown in Chart II, was kept for each member of the class. It has been found that the course can be completed in nineteen weeks providing the

student spends at least five hours outside of class and four hours per week in class.

At one time there were eighteen ex-servicemen enrolled in the physics course. Any evening a visitor in the class could see men working in one of the following activities such as text study, problem solving, solving exercises, conducting experiments, or taking an examination. On the average, there was a new member entering the class once a week during the first eleven weeks. Some students progressed through the units at a fast rate, while others were quite slow. These factors resulted in a distribution of the students from unit one to ten.

The veterans desired a physics course for one of the following purposes: to obtain a high school diploma, requirement for

CHART I.

special college courses, refresher course, and a requirement for special work in industry.

From these straight and forward-thinking G.I. Veterans have come comments concerning the course. They say this kind of instruction is superior to what they had before the war. In their words it is now "Education with a new objective and real purpose."

It is possible that our present method of instruction with high School students might be changed to more nearly compare with that offered to these men. The writer feels that it is worth the effort. With that in mind, the plan is being instituted with a class of thirty selected students in physics. The results at the end of the year will determine the success of the plan.

CHART I.

MECHANICS OF GASES—UNIT III*

Introduction

Barometers play an important part in the forecasting of weather. It is also an important instrument aboard ship and planes. "Boyle's Law" is one of the time tested laboratory experiments. Practical applications of compressed air are pumps, caissons, air brakes, submarine, and siphon.

Directions

I. Read Chapters 3 and fill in Ex. 6, page 37; Ex. 7, page 41; and Ex. 8, page 43 (min. assign. part A only, max, assign. parts A & B). The equipment located at station C will help you in securing correct answers for the exercise blanks. *Get Ex. 6, 7, & 8 checked before proceeding.*

II. Write out the solution to the following problems—No. 1, 2, & 5, page 62; No. 1, 3, & 5, page 73; No. 1, 2, 3, & 4, page 85. (max. prob. assign.—problems in part B located on pages referred to above.) Get the problems checked before proceeding.

III. Work Exp. No. 9, page 19; and No. 10, page 21 which are located on the north bench so marked. Get them checked before proceeding further.

IV. Review the points in the test entitled, Mechanics of Gases, page 45. You may now take test No. 3 which can be secured from the instructor.

V. You are now ready to start on Unit 4.

* One of the nineteen units based on the outline of course content found in Charles Dull's "Modern Physics" text and (Revised) Physics Workbook.

CHART II.

PROGRESSIVE ACHIEVEMENT RECORD IN PHYSICS

	Unit III					Unit IV				
Student's Name	Exercises 6, 7 and 8	Problems Pages 62, 73 and 85	Experiment 9, 10	Test No. 3	Average Grade	Exercise 12, 13 and 14	Problems 123and 131	Experiment 11, 13	Test No. 4	Average Grade
1.										
2.										
3.										
4.										
5.										
6.										
7.										

Democratic government can be predicated only on universal education. —Inscription on the Pennsylvania State Education Association Building, Harrisburg.

THE SLIDE RULE IN JUNIOR HIGH SCHOOL MATHEMATICS

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An article with the above title would have made teachers of twenty-five years ago throw up their hands in horror. However the world has been moving rapidly in the past two decades and mathematics has been keeping in stride. Our experiences coming out of the war have caused some consternation and a great deal of thought provoking study on, "what and how." In mathematics teaching we have found many of our students with less real knowledge than we assumed they had. We found our students needing more and still more mathematics. We found our leaders demanding more thinking of the type we do in mathematics. We found our students unable to reproduce those facts we thought they had learned so well. In the light of this discouraging discovery we have thoroughly scrutinized our program to determine the weaknesses of the past and possible strengthening for the future.

One of the factors brought out in our analysis was the need for more thought during manipulation. It is this factor that we wish to emphasize in this paper even though the title infers we are bringing in a labor saving device or a mechanical machine to do our thinking for us. Our premise is just the opposite. We maintain the slide rule, if used properly in the Junior High School, is a thought provoking instrument. There are few schools which have taken advantage of the slide rule as an upper elementary teaching device. The reasons for this are evident, in that very few of these teachers have had the opportunity to use or in many cases even see and have explained the method of operation. Slide rules of 15 years ago did not appear on the open market such as drug stores, 5 & 10 counters, etc., at prices similar to that of paper and notebooks. The slide rule was looked upon as an engineer's tool to be used in complicated processes only after much study and practice. Approximate computation in the junior high school was unheard of and the only talk of significant figures, degree of accuracy and precision was in the technical schools. The boys and girls growing up 15 years ago did not see page after page of advertising, with the slide rule as one of the prominent items in the picture, as they do today. The slide

rule being based on logarithms was considered too complicated until after the study of logarithms. For all these reasons the slide rule has not been made a part of the instruction in the junior high school in as many places as should have been the case.

However there are several reasons why it is a valuable instructional aid even though it is also a mechanical device for getting results with more speed. Junior high school pupils are enthusiastic, alert, curious and ambitious, they only need motivation and guidance in the right direction. They have studied the fundamental processes and various applications. They have solved many problems well, but mastery is not complete until retention is raised to a high level. For this reason we tend to repeat, drill and reteach much of the material given in the previous grades. This has been found to be necessary and wise. The slide rule provides a new method of arriving at the old conclusions and gives the student a purpose for further practice. He knows this instrument is used by many and feels he has arrived at adulthood when using a man's tool with a purpose.

We believe the pupil should develop the ability to preestimate his result to better check on errors as he proceeds with a problem. We have no way of reading the pupil's thoughts as he works and his estimates may turn into guesses but with the slide rule the digits are provided and he must determine the size of his number by mental arithmetic and thought. He sees the value of such work on estimates, while he may use the pencil mechanically. The teacher has a surer check because the pupil's first result will picture his type of thinking and problem analysis. Pupils have been using decimal fractions for several years in everyday affairs and in school but the concept seems to be elusive. The decimal point is readily placed if they are allowed to merely count, but what of the many times in daily life decimal quantities are referred to as amounts, and in comparing sizes? Here the pupil must think in quantitative terms and here is a weak spot in our teaching of the decimal. If the pupil is asked to analyze the position of the decimal point after a longhand multiplication he does not think about size, in fact it is difficult for him to do so with the crutch of counting out the number of places so close at hand. Is it any wonder a student will multiply .2 by .3 and get .6? With his slide rule there is no aid; he must think in terms of the comparative size of the numbers with

which he works. It is true he should do this in all cases but it is so easy to be lax in our thinking. Every quantity handled on the slide rule must be thought about quantitatively. The above is one of the basic aims in the teaching of mathematics, therefore how can we afford to pass such an opportunity for fulfilling this aim?

As part of our maintenance program it aids in the clarification of reading a measuring rule of any kind and brings more meaning to the study of preciseness. Seldom do we have before us a rule which shows at least three degrees of precision and the opportunity to use them in the same operation. Many pupils are familiar with rulers marked off in eighths, fourths etc. and the slide rule provides an excellent device, which is new and interesting, with which to practice the fundamental principles.

We fully realize the principle that there is no one way of teaching a subject but we present here a plan of instruction of the slide rule in grades 7 and 8 which has proved successful with several groups of pupils. The materials are not expensive, a 25¢ rule for each pupil will suffice. If at all possible a 6 foot demonstration rule should be provided. If this is impossible slide film and movies may be rented from the different University Bureaus of Visual Aids.* There are a number of topics where the slide rule may be introduced, problems dealing with area, fractions, percents, and decimals. There is one word of caution at this point, the slide rule is not a substitute for the 100 fundamental combinations. These must be mastered first but the slide rule can then provide a good means of checking the pupil's ability to handle them. As an illustrative problem suppose we take the unit on area. First we would hang the demonstration slide rule in the front of the room without comment. Then give the pupils a simple problem such as finding the area of a rectangle using not over three digit numbers. After they have finished and if there happens to be several different results use the slide rule to check the result. After several problems have been checked in this manner the pupils will want to know how you can check them so rapidly. Now is the time to do several for them to show speed and ease. When introducing the principles of the rule the best logic to follow is perhaps the relation between addition and multiplication. Most of your students will know nothing of logarithms and exponents so this approach

* Indiana University, Bloomington has for rent 36 slide rules and also a film on slide rule operation.

should not be used unless you wish to take time for a simple explanation of them. The method is simple and since they are to apply it immediately a complete understanding of the underlying principles is not absolutely essential. However if the better students want the why, be sure to provide it for them. After simple multiplication has been performed and we get to larger numbers and decimals we meet the problem of reading the scales. Here we bring in the rulers they have used in the past and compare the unit marks. In the light of the ruler they determine the various units on the slide rule. This accomplished we proceed to the quantitative aspect of our results which is where the pupils do their hard thinking and this is just where we feel they should do the hard thinking.

Occasionally we have a boy who does not care to discard the tried and true method of longhand because he is accurate and fast. We then choose one of the better rule operators and give them both the same problem to solve. Usually the boy using the rule will complete the problem first, if not we can still make a favorable comparison by considering the amount of time each has spent in practicing his method. If there are no ratio or division problems in this unit on area we omit it for the time being. Our pupils now have the privilege of using the slide rule in all problems where the precision of the problem allows it, which is in most cases. We may give drill on the combinations where the rule is not allowed but only in such drill problems. The pupil carries his slide rule with him as he does his pencil, he uses it in other classes and will use it for years to come in business, industry and science.

The slide rule should become as much a regular part of the equipment of the junior high school mathematics student of the future as the pencil, paper, blackboard, and chalk is today. If we as teachers of mathematics fulfill our obligation of making the pupil think in quantitative terms we must use every available piece of equipment for the production of such thinking, and the slide rule is definitely this type of equipment.

NATIONAL COUNCIL OF GEOGRAPHY MEETS AT COLUMBUS

The annual meeting of the National Council of Geography will be held on December 27–28 at the Neil House, Columbus Ohio. Katheryne Thomas Whittemore of State Teachers College, Buffalo, New York is president of the council. This will be the first meeting of the council for five years.

SOME WAR-TIME DEVELOPMENTS IN CHEMISTRY

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VI. Petroleum

War-time demands upon the petroleum industry were centered around both quantity and quality. The outstanding achievements of the Petroleum Administration for War and of the petroleum industry itself stand as a monumental tribute to "the resourcefulness, untiring and unceasing efforts and outstanding accomplishments" of an agency which is said to have done "the best civilian war job" during the critical period of World War II.

From the standpoint of processing the greatest developments in the petroleum industry have been made in the fields of catalytic cracking, alkylation, superfractionation, and the production of such products as butadiene, toluene, lubricants and organic synthetics. In general the advantages in the catalytic cracking processes over the former heat methods come from the fact that they yield more of the materials used in the production of aviation and other high grade gasoline. The great disadvantages have been that the equipment required is large and expensive and that the operations are complicated. Much has recently been done to simplify both plant and its operation. As a result small cracking plants are now employed by the small refineries and catalytic cracking will undoubtedly supply a large part of the gasoline for general use, just as it was a major factor in the production of aviation gasoline for military purposes during the war.

Without doubt the most significant single item in the production program was in the huge supply of 100-octane aviation gasoline, which was furnished the armed forces. At the peak in July 1945 the United Nations, excluding Russia, reached a total production only a little less than 600,000 barrels per day. Of this amount, which was ten times the prewar capacity, refineries in the United States produced more than 87%. The remaining 13% came very largely from refineries which were financed at least in part by American capital and operated by skilled American technicians. This remarkable production record has been called "the largest single task in organic chemical synthesis

which has yet been undertaken." The importance of the chemist is shown by the fact that the product was a skillfully prepared blend, 30% of which was composed of synthetic hydrocarbons of the iso-octane family. These were produced in some 75 alkylation units which used either hydrofluoric acid or sulfuric acid as catalyst. The purely chemical product, which was known commercially as "alkylate," was produced mainly from isobutane, normal butane, butylenes and other similar materials which came from the catalytic cracking units. Both natural and synthetic isopentane were also used in producing aviation gasoline and contributed materially to the total yield.

The aviation gasoline produced during most of the war period was known as grade 100–130. In the summer of 1945 the industry began the production of a superfuel which was known as 115–145. These numbers refer to an extension of the original octane rating and indicate the superiority of the new fuel. In the latest type of engines, this gasoline permitted a faster take-off and a longer cruising range than had ever been possible before.

In addition to meeting the demand for aviation gasoline, the petroleum industry had to supply huge quantities of material for many other purposes. In 1945 there were produced daily over 200,000 barrels of 80-octane gasoline for the operation of the multitude of cars, trucks, jeeps and tanks which were essential parts of military operations on the ground. The production of distillate and Diesel fuels averaged 700,000 barrels per day. Fuel oil was in heavy demand especially for the naval operations in the Pacific. At the peak of the struggle the United Nations required over 2,300,000 barrels of fuel oil per day. Lubricating oils were also in heavy demand for aviation, for ground vehicles and for naval craft. Outstanding developments have been made in the field of lubrication and these will undoubtedly be used in post-war industry. Among the developments may be mentioned heavy-duty oils for tanks and heavy machinery; low-temperature greases which will be useful in arctic regions and in refrigeration equipment; new rust-preventing compounds and superior cutting oils which will find useful applications in industrial pursuits.

Another important contribution made by the petroleum industry was the production of butadiene for the manufacture of rubber. There has been keen rivalry between alcohol and petroleum as a raw material for the large scale production of butadiene. Cost studies, at present, favor the use of petroleum,

but if the supply of petroleum decreases materially, it is possible that alcohol may eventually win out in this rivalry because the source of its raw material is renewed yearly. In the petroleum industry, butadiene was obtained mainly by the catalytic hydrogenation of butylene which was also used in making the alkylate for aviation gasoline. So the supply of butylene had to be allocated between the two vital processes of manufacturing aviation gasoline and the production of synthetic rubber. To increase the supply of butadiene, other chemical sources were utilized such as the dehydration of butane, and the thermal treatment of naphtha.

Smaller in volume but equally essential for success in military operations was the supply of toluene used for producing fog as a protection against air raids as well as for the manufacture of TNT. Formerly toluene was exclusively a by-product of the coal tar industry, but war-time demands quickly exceeded the supply from this source. Recently the amount of toluene obtained from petroleum has far exceeded the volume obtained from coal tar. It was produced from petroleum materials by extractive distillation and by catalytic dehydrogenation of methyl cyclohexane. It is likely that the peace-time demand for toluene will be met by its recovery from coal tar. This will permit the cyclohexane material to be used in improving the octane rating of gasoline.

In addition the petroleum industry was called upon to produce jellied gasoline which made the most effective incendiary bombs and fuel for the deadly flame throwers. The technique of superfractionation was vastly improved and as a result the petroleum chemist has contributed large quantities of styrene, alcohol, cumene, acetone, methyl alcohol, formaldehyde, vinyl chemicals, glycol, waxes, naphthanates, wetting agents, detergents, cresylic acids and even phthalic anhydride.

This is an imposing array of contributions made by a single industry. It was made possible only by the program of intensive research which was inaugurated before the war and continued with increased vigor during the war years. The research effort now will undoubtedly be shifted to peace-time needs, and we may look for splendid contributions to our modern way of living. Fortunately for the industry the transition from war to peace has not presented insurmountable difficulties and many of the advances made during World War II will find useful application in modern industry.

Such an enormous drain upon one of our most important

natural resources leads us to wonder how long the industry can continue on the present basis. Fears have been expressed upon numerous occasions that the nation is wasting its precious raw materials and will soon face a genuine famine in petroleum and its multitude of useful products. The United States Department of the Interior has estimated that our petroleum resources, at the rate of consumption for 1935–39, would be exhausted in 18 years. The accelerated use during the war years must certainly bring this period of exhaustion uncomfortably close. Even with the possibility of the discovery of new oil deposits and the utilization of oil from oil shales, it is obviously that conservation of this important resource is essential for future developments While reasonable economy is wise, some petroleum experts call attention to the possibilities of obtaining liquid petroleum products by synthesis from natural gas or from gas producible from coal. Pioneer methods are already available for these processes. Two plants with a daily capacity of 6000 barrels are already planned for the southwest. They are expected to go into production within two or three years. When these processes are perfected it is possible that liquid fuels and other products now obtained from petroleum may be manufactured at a cost not too much above present levels.

VII. Wood

Wood has been an indispensable material of construction through the ages since primitive man first began to make artifacts and to build shelters for himself. During the period of World War II wood has assumed a new importance not only because of its own useful properties, but also because of the shortages of metals and raw materials for making plastics. During recent years many advances have been made in the treatment of wood with consequent expansion of its usefulness. These developments will readily become adapted to peace-time uses, and the fact that wood is a raw material which by reasonable foresight is constantly being renewed strengthens the belief that wood is destined to continue its useful service for many generations.

Plywood was used 15 centuries before the Christian era, but its developments within the past few years have been remarkable. It was used extensively during the war as a substitute for scarce metals and its success was so marked that it has now joined the ranks of big business and it is entering competition

on its own merits. The annual production is reported to be valued at $75,000,000. The chemist has contributed to this progress by furnishing adhesives which permit wood lamination to reinforce each other as well as glass, textiles, paper, plastics and thin metal sheets. The kind of glue used goes far in determining the strength of the bond between the surfaces, the ease of forming desired shapes, the machinability of the product and its ability to resist weathering, dampness, fungus, heat, shock, vibration, stresses and other destructive influences. The finished plywood combines lightness and strength and the ease with which it may be shaped either before, after or during the glueing process makes it readily adaptable for use in contoured applications. During the war plywoods were used in the manufacture of many forms of military equipment, notably the Mosquito Bombers. Their efficient service under severe war conditions presents a challenge to designers of peace-time equipment. Already this versatile material is being used by builders of airplanes, prefabricated homes, furniture, containers of various sorts, cold storage chambers, tanks, bins, silos, and whereever stiffness, strength, and lightness are desired. An additional factor is the ceonomy involved in the use of plywood as in the conservation of expensive varieties of wood. If a log is cut into lumber only about 20% of its weight is utilized while if the log is cut into veneer and made into plywood as much as 85% can be used. This is an important factor in the conservation of our forest products. Many developments in the use of plywood may be expected.

The importance of wood preservation has been emphasized during the war period by the increased demand for such items as railroad ties and telephone poles. Coal tar creosote has been almost the only wood preservative used in this country as is shown by the fact that in 1944 creosote was used in treating over 96% of the 278 million cubic feet of wood which were subjected to wood preservation. As creosote became scarce other similar materials were mixed in, such as water-gas tar, wood-tar creosotes and the like. It was found desirable to use at least 50% coal-tar creosote. It was determined also that pentachlorophenol is 10–100 times as toxic as coal-tar creosote and that a 5% solution of it in spent crank-case oil was efficient in preventing decay. This solution also had the advantage of high penetrability, which increases its efficiency as a wood preservative. The Navy also used copper naphthenate for the preservation of wood

which was to be used in the construction of boats. This material is available in considerable abundance since the naphthenates are by-products of the petroleum industry.

The impregnation of wood is another process which is receiving attention because it may be made to increase or create desirable properties. Many chemicals have been tried out for this purpose, but the effect of dimethylolurea may be taken as typical. When woods are impregnated under pressure, the hardness is increased up to 30%, the transverse strength is greatly increased, the workability is improved in many varieties, and resistance to chemicals is increased. The process may be used to impart some desired colors to the wood. At present this process is used with success in making small tool parts, such as handles, but it is capable of extensive development. Other urea derivatives are used to decrease the tendency to swell, shrink or warp and to increase hardness, strength, density and durability. Impregnation is also performed with resin, acetylating agents and hydroxylin, a low-cost plastic material made by hydrolyzing wood.

VIII. Utilization of Waste

The American wood industries have always been very wasteful of raw materials. It has been estimated that "from one-half to two-thirds of the nation's annual wood crop is now lost as woods and mill wastes." As wood and wood products become more scarce, here is another gift of Nature which needs to be used with a greater consideration of future needs.

The shortage of sugar and alcohol during war years has greatly stimulated the utilization of wood waste. The Scholler process has been studied and modified in this country. See Organic Materials, This Journal, October 1946, p. 617. The yield of wood sugar from some varieties of wood equals 57% of the weight of the dry wood. In Germany the Bergius method was employed. In this method hydrochoric acid is used in an elaborate extraction system from which wood sugar equal to 60% of the dry wood is obtained. The purified product contains about 70% dextrose and 30% of a mixture of the monosaccharides xylose, arabinose, mannose and galactose. The wood sugar, obtained by either method, may be used in the production of a great variety of products by the aid of micro-organisms, and such by-products as tannin, lignin, butyl alcohol, acetone and isopropinol may be recovered. One important product is a

high protein stock feed. It is claimed that by present procedures, one cord of wood can be converted to one-third of a ton of feed, approximately equal to the protein content of 50 bushels of corn. In Germany where coal and petroleum were scarce, chemists not only made food out of wood, but textile fibers, and both solid and liquid fuels. In 1939 Germany had nine factories with a total capacity of 150,000 tons of crude wood sugar. Alcohol is readily obtained from wood sugar as well as from the waste sulfite liquor of the wood pulp industry. An alcohol plant at Springfield, Oregon, is expected to produce nearly 6,000,000 gallons of alcohol per year by the hydrolysis of wood waste.

Lignin has been called "the greatest waste in industry." This is an amorphous material of high molecular weight and only partially characterized structure. It is a non-polysaccharide in which the cellulose fibers of wood are imbedded and which make up from 20 to 30% of wood. Lignin must be removed in the production of cellulose for the manufacture of fabrics, paper, nitrocellulose and other products. This is accomplished by digestion under pressure with calcium sulfite, sulfurous acid or, recently, magnesium or ammonium sulfite. The use of the latter eliminates the serious problem of waste liquor disposal. Most of the lignin is useless, and its disposal involves some difficult problems. It is usually burned or discharged into a river. Estimates state that the pulp and paper mills have polluted streams with as much as 2,500,000 tons of lignin per year. In addition to this large supply, the waste from sawmills and wood-working plants could probably supply annually an additional 10,000,000 tons of lignin. Farm wastes add a potential 38,000,000 tons of lignin per year and the natural growth in forest and field are adding to our store of lignin at a rate somewhat in excess of 150,000 pounds per minute. Many attempts have been made to use the sulfite liquor which contains lignin for the production of material which might be used for road building, tanning of leather, electroplating, fermentation, and in the manufacture of adhesives, detergents, alcohol, vanillin, dyes, insecticides, fertilizers and plastics. Many of these processes have been successful to a limited degree, but good authority states that all these uses put together would utilize not more than 38% of the enormous supply of lignin in the sulfite mills of the United States. A $300,000 research program is now under way to find more uses for sulfite liquor or to increase the usefulness of some of the products readily prepared from it.

Lignin itself has been studied carefully. In Germany medicinal carbon has been prepared by charring lignin. In this country valuable chemical agents have been made from lignin, such as phenols, cresols and many others. Agricultural waste like corn cobs, peanut shells, flax shives, oat hulls and cottonseed hulls have been used for the production of a liquid motor fuel. As much as 95 gallons of fuel have been obtained from a ton of corn cobs or cotton seed hulls. This process is being tried out on a semicommercial scale.

IX. Corrosion

One of the most serious problems which modern science must face is the corrosion of our metals. The shortage of metals during the war and the necessity of protecting metal surfaces from corrosive influences have greatly stimulated efforts to prevent losses from these destructive forces. Recent estimates have indicated that losses from corrosion are enormous. Good authority indicates that in normal times one-sixth of the iron products manufactured are required to replace metal which has been made useless by rust. The annual loss from corrosion in this country has been estimated at more than $200,000,000.

Our greatest concern in the problems of corrosion is in regard to the behavior of iron, which as an active metal rusts rapidly under certain conditions to which it is frequently exposed. The most susccessful method of preventing the corrosion of iron is to alloy it with some such metals as copper, nickel or chromium. Stainless steels are popular in cutlery, as decorative metal in automobiles and buildings and as linings for chemical manufacturing equipment, on account of their efficiency in resisting corrosion. But they are obviously too expensive for use as structural steel, railway rails or for heavy machinery. Other methods of slowing down the corrosion process include the use of a protective layer on the surface. These include paint, a layer of a less active metal, dipping in various types of baths to protect the surface, to induce a degree of passivity or to inhibit corrosion.

In prewar years a vast amount of effort was put into the prevention of corrosion, but the results at best were only partially successful. With the outbreak of the war the problem was greatly intensified because metal machines and repair parts had to be shipped great distances and were exposed to heat and salt spray. If machines were not protected from these corroding in-

fluences they might arrive at destination so badly rusted as to be useless. As a result great strides have been made during the war years in perfecting the packaging of metallic materials, so that on arrival at a distant point the metal surfaces were free from rust and ready for immediate use. These developments are even now being applied to civilian use, and manufacturers of metal products are no longer concerned about the danger of corrosion in storage or in transit. We may now expect to buy in individual moisture-proof packages such articles as watches, compasses, typewriters, sewing machines, adding machines, outboard motors, and many other items which might deteriorate in store room or sales room.

The corrosion-proofing of small metal objects or spare parts is accomplished by thoroughly cleaning the object then dipping in anti-corrosion wax or in a hot bath of orthophosphates, ethylcellulose or similar material. Protection is complete for an indefinite period and when wanted for use, the coating is easily and quickly removed. Larger units like sewing machines are sealed in waterproof, vaporproof, transparent bags and all enclosed moisture taken up by suitable dessicating agents. This method, applied to over-seas shipments during the war was highly successful in delivering military equipment "at the battlefronts as clean and rust-free as it had been on the assembly line back home."

At the conclusion of the war the Navy was confronted with an unusual and difficult problem in rust-proofing some 2200 vessels which were to be stored in stand-by condition. It was necessary to store these ships under conditions which were favorable to the corrosion of the metals which make up such a large proportion of both boats and equipment. Compartments were thoroughly cleaned, then all corrodible surfaces were coated with a thin film of rust preventive compound. Finally the compartments were sealed and the ventilating system was put into operation to remove moist aid and replace it with dry air. Large metal equipment like a winch on deck was first wound with a network of scotch tape which serves as support for a film of plastic, applied by a spray gun. Other layers of plastic build the film up to a quarter inch in thickness and a final coat of aluminum paint was added to protect against the heat of the sun. A dessicating agent such as silica or activated alumina was placed under the cover to remove moisture. Such a coating is estimated to keep metal parts bright for as long as 15 years and

the "strippable" film may be removed quickly. The guns of a war ship are protected in a similar way. Armor plate, especially below the surface of the water is coated with a plastic poisonous paint both to check corrosion and to prevent the growth of barnacles.

The rust proofing of small units of iron, steel or zinc has been widely accomplished since 1915 by Parkerizing. This consists of submerging the metal parts in a hot (175°–212°F) solution like manganese dihydrogen phosphate for 10–60 minutes. A thick layer of phosphate adheres to the metal and this in turn, must be protected by a layer of oil or paint. In 1930 the Bonderizing process was introduced. This permits the application of a thin phosphate coating by spraying, the time is reduced to 60 seconds and a lower temperature is permitted. This thin coat of phosphate is especially suitable as a base for paint or the silver-plating of steel. Both these treatments produce a hard crystalline coating which is easily broken. During the war a new method of phosphating was perfected for steel shell-containers for use in the Pacific. A coating of metallic phosphate is given a surface by spray, immersion or brush at room temperature. The coating is 5/15 millionths of an inch in thickness, is more effective in preventing corrosion, permits a tighter bond with paint and is plastic enough to bend with the steel or to permit die-stamping. The process is simple, effective and economical. It is now being used in the finishing of automobiles, refrigerators, gas and electric stoves, deep-freezing units and many other household appliances, to which it promises to impart greater durability and longer life.

One of the most costly and annoying corrosion problems comes from the fact that iron pipe buried in the ground will frequently corrode with surprising rapidity. Just before the war broke out experiments were conducted to determine how much protection could be obtained by burying an ingot of magnesium near the iron pipe and connecting the two by a copper wire. It was found that the magnesium, serving as an anode, was corroded, but gave the iron pipe "cathode protection" from corrosion. Now that magnesium is readily available this process seems likely to become very popular in those areas where the soil corrosion of iron pipe is pronounced. The anodes of magnesium alloy (such as those containing Al 6%, Zn 3%) weigh from 17 to 50 pounds. They are buried in a post hole about 10 feet from the pipe and are surrounded with a mud of

bentonite clay and gypsum. This lowers the resistance of the circuit and controls the consumption of magnesium. A copper wire connects the anode with the iron pipe. Under very bad conditions anodes may need to be as near together as 20 feet but when conditions are better they may be several miles apart. The life of the anode depends upon its size and the amount of current which it supplies. A 17-lb. ingot will last from 1 to 10 years. Its replacement is much less troublesome and cheaper than the replacement of the iron pipe.

The corrosion of metals other than iron has not been so serious a problem, but losses from this source have been considerable and efforts to prevent corrosion of nonferrous metals are being made. A new corrosion inhibitor for copper and its alloys, known as "brass lyfe" has been announced by the Bee Chemical Co. of Chicago. The corrosion of aluminum has been studied and it is believed that corrosion of this metal is due to its crystalline structure and electrochemical nature rather than to a lack of homogeneity, which is believed to cause much of the corrosion of iron and steel.

This review of some of the advances made in chemistry during World War II is designed to call attention to the rapid strides which have been made during the period when secrecy was a necessary rule. It attempts also to call attention to the ways in which these advances may be adapted to postwar needs. The review is not exhaustive for there are many other ways in which chemistry is daily becoming more useful in our modern way of living. It is to be hoped also that these studies may suggest to the readers other problems which need to be solved and other research projects which should be undertaken to add to the progress of civilization.

AMERICAN ASSOCIATION OF JUNIOR COLLEGES

THE 27TH ANNUAL MEETING OF THE AMERICAN ASSOCIATION OF JUNIOR COLLEGES WILL BE HELD FEBRUARY 19–22, 1947, AT THE HOTEL JEFFERSON, ST. LOUIS, MISSOURI

A NEW APPROACH TO THE BAROMETER

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The traditional barometer demonstration in which a thirty-five inch tube is filled with mercury and then inverted in a well, requires a good deal of explanation for the average general science class. Experience with junior high school students led to the development of the following series of demonstrations and suggested questions.

In the first step a tumbler is filled with water and inverted in the water in a battery jar. Even when most of the tumbler is thus lifted out of the water, as long as the lips are below the surface in the battery jar, the tumbler remains filled with water. Question—"Why doesn't the water come out?"

In the second step a long tube, 45 inches or more, sealed at one end, is filled with water colored with ink. This may be done from a beaker if the hand is steady and the diameter is great enough. The tube is then inverted with the open end below water in a beaker in the traditional barometer fashion. Question —"Why doesn't the water come out"?

In the third step a 24″ glass tube sealed at one end is filled with mercury and inverted over a dish of mercury. Question— "Why doesn't the mercury come out?"

In the fourth step, a 35″ barometer tube is similarly set up. Questions—"Why were the tubes of various lengths used? What is in the space above the mercury in this tube? How much heavier is mercury than water? What keeps the mercury from flowing out? Why does the mercury drop to a height of 30″ and no further? What would happen if the upper tip of the tube were broken? How long a tube would be needed in order to use water in the barometer? Can a barometer be made using a tube which is open at both ends?"

A fifth step may be performed in which a 35″ tube open at both ends is connected with an aspirator or exhaust pump. If the other end is placed in mercury, it will be shown that the mercury will rise to a height of 28″ or so. With water, of course, the tube will fill and pour out.

A sequence such as this serves the purpose of building up to the generalizations involving vacua, air pressure, and measurements. This step-wise procedure arouses interest and participation even in the lower junior high school grades.

WORLD PATTERNS FOR PEACE

A RESOURCE UNIT IN POLITICAL GEOGRAPHY AT THE HIGH SCHOOL LEVEL

JOHN H. GARLAND
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The high school is the place to direct the thinking of the young American citizen towards world mindedness; it is the place to help him become a broad and intelligent citizen of the world, for it is at this level that he is first able to appreciate clearly concepts of world magnitude. Thus it is the place of geography to make contributions of a world pattern nature to the thinking of the high school student. Secondary geographic thinking begins when a comprehension of world patterns is first reached. The initial level is chiefly concerned with the world commercial relations of the homeland developed in the junior high school whereas the advanced concepts of world patterns of economic, social, and political structures in association with the major patterns of the natural environment are developed in the senior high school. As a culminating effort problems concerning world patterns of nations lead in the direction of the desired type of thinking. In keeping with this concept the following is presented as resource material at an advanced secondary level.

WORLD POLITICAL PATTERNS

As we look at the world today the solution to total peace seems to lie in the mutual understanding and cooperation of all nations embodied in some type of effective world organization that transcends the total power of any individual nation. Today three major national powers stand out: The British Empire, the Union of Socialist Soviet Republics, and the United States of America (Fig. 1). Around these are grouped lesser nations of varying degrees of magnitude. It is quite possible that each of the big three, which are actually unions of lesser states themselves, might become the center of gigantic zones of influence which would extend the power politics so long practiced in Europe to world wide proportions. On the other hand the three major nations might form the core of world political integration based upon international law and order. Whatever the possibilities, a brief sketch of the geopolitical structures of the three major nations might be enlightening in view of post war patterns of world development.

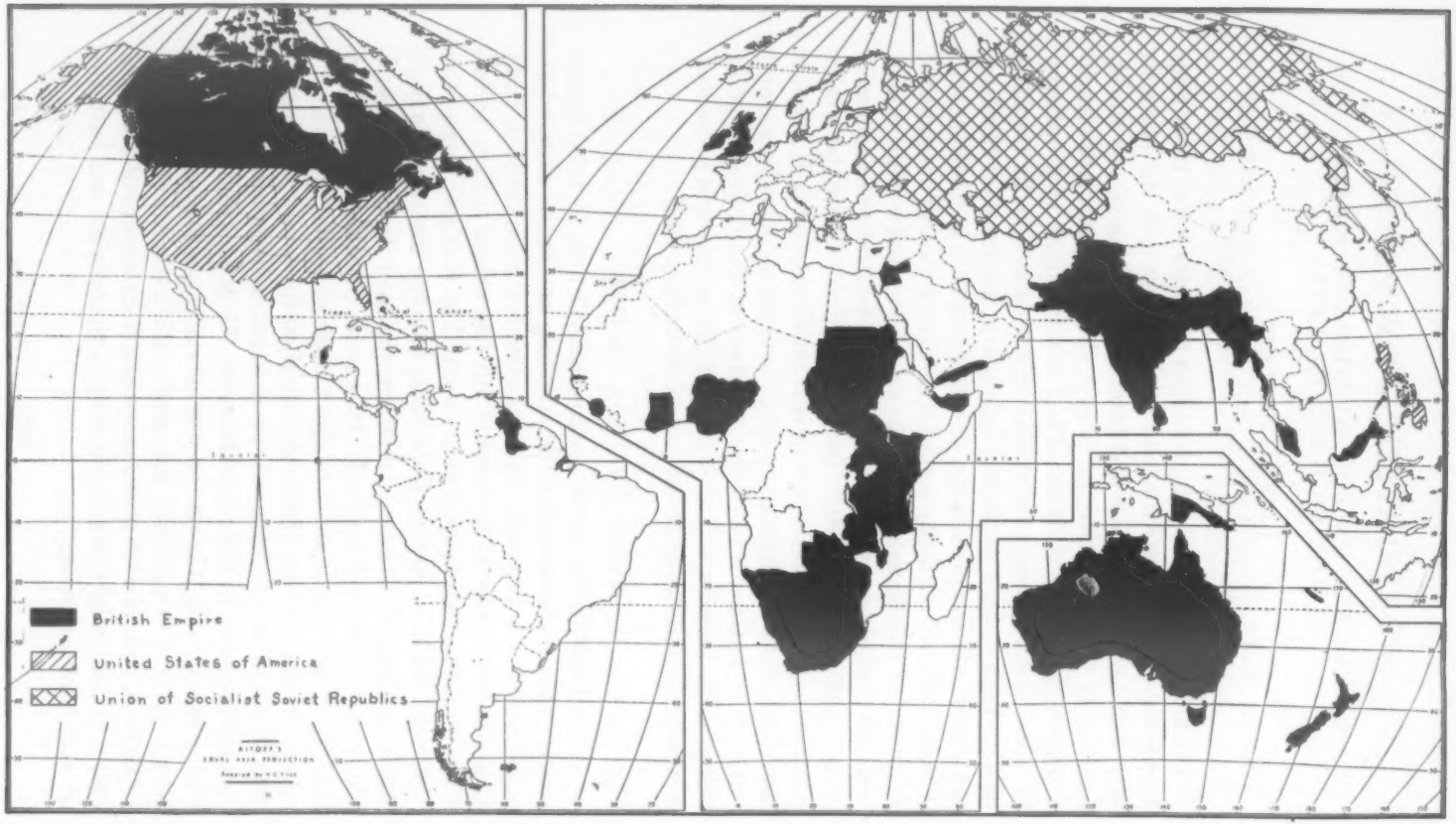

FIG. 1. Geopolitical Patterns of the Three Major National Powers.

Geopolitics, or perhaps more properly political geography, is concerned with the fundamental earth-state associations and relationships. The people of the state are its dynamic elements, whereas the earth is its passive basis. The total potential wealth of a state is dependent upon the portion of the earth so occupied, whereas the actual strength of the state is a measure of human accomplishment within the earth-bound framework. Within the broad earth-state relationship the most conspicuous global features that color the geographic personalities of states are the land-water or continental-oceanic relationships. These have given rise to the concept of sea powers and land powers, or marine states and continental states. The sea has long been the basis of national mobility, the medium over which goods and ideas from the far corners of the earth have been exchanged. Global mobility has been the national strength of those states favored by oceanic positions whose peoples have been disposed to take advantage of it. On the other hand continentality, until the development of modern land transport, has been generally devoid of mobility, and national strength is rooted in the earth immediately occupied by the state, that is, its natural environmental resources. It is well to note here that air power has not motivated another type of state for air routes apply equally to land nations and sea nations alike.

It is obvious that as the modern world political pattern was developing and crystalizing the advantages of the marine state greatly outweighed those of the continental state. Modern technology, although applying to the sea as well as to land, has greatly cut down the differential. The conflict of land and sea policies has long dominated European political relations reaching its zenith in World Wars I and II. It is just this pattern of conflict that Mackinder[1] was dealing with years ago, when, in his "Geographical Pivot of History," he tried to point out to a commercially sea-minded nation that "ruling the waves" was not sufficient protection against the rise of a vigorous land based nation in the Eurasian continent. Again in 1919, just after World War I, he[2] warned against the same dangers. Likewise the reverse of this same pattern, or the strength of a modern land based state was the basis of German aggressions and the gradiose plans for world power.

In the light of continental or oceanic relationship let us ap-

[1] H. J. Mackinder, "The Geographical Pivot of History," *Geographical Journal*, 1904, pp. 421–444.
[2] H. J. Mackinder, *Democratic Ideals and Reality*, Holt, 1919, 1942.

FIG. 1. Geopolitical Patterns of the Three Major National Powers.

praise the three leading nations on whose shoulders will rest the future world policies—Great Britain, the Union of Socialist Soviet Republics, and the United States of America. Great Britain as the core of the British Empire is the world's number one sea based nation, whereas the Soviet Union with very limited access to sea is not only the world's largest nation but also the most continental of all nations. Between these two extremes is the United States, the most developed of all continental nations with an adequately functioning frontage on two oceans. Thus, the United States partakes of the advantages and disadvantages of both types of state structure.

Great Britain

There is little doubt that the protective qualities offered by insularity were of inestimable value in the early crystalization of the British state. Yet the same limited space of the islands was the greatest drawback to increasing national strength. British geopolitical strength is embodied not in the islands but in the global position of northwest Europe. The British were the first to grasp the full significance of their situation and to translate the understanding into complete action. Any other northwest European state might have done the same thing; but the British were the first to put the world plan into action thus establishing the present British way-of-life which has come into conflict with the activities of other states from time to time. The fact that densely populated northwest Europe is the most easily accessible point by sea to the greatest portion of the populated world is the greatest single earth condition that the British have utilized in building their geopolitical structure. The true relations of the occupied portions of the earth are due to the arrangement of continents and oceans. This is such that the greatest number of great circles or shortest routes from the inhabited portions of other continents focus on northwest Europe. A string stretched tightly over the globe demonstrates them best. The north Atlantic route from North America, the Mediterranean-Red Sea route to the Malay Peninsula, eastern Asia, and Australia; the south Atlantic route to South America and its associated south African route—the predecessor of the Suez or life line—the Caribbean-Panama-South Pacific route to New Zealand, these are the lines along which ply British ships filled with British goods made with British coal at the ends of which are members of the British Commonwealth of Nations. Thus

was the British geopolitical pattern forged, a world power based on marine mobility which is related directly to the earth resources of sea position and accessibility, and is protected by the British Navy and the Royal Air Force.

Union of Socialist Soviet Republics

At the other extreme is the vast continental nation of the Union of Socialist Soviet Republics encompassing one-sixth of the land area of the world wherein live nearly one-tenth of the world's population. Its gigantic proportions can best be appreciated when we realize that transferred to the Western Hemisphere Leningrad in the west would be near Nome, Alaska whereas, eastern Siberia would touch Norway, and although the Arctic coast approaches as close to the North Pole as does the Canadian Arctic, the southern most limit would reach the latitude of Tennessee. Size—continentality—is the basis of both the strength and weakness of the Soviet nation.

It must not be imagined, as some enthusiastic supporters of communism would have us believe, that this huge land is constituted only of the world's most fertile soils and greatest mineral wealth. Neither should we be unduly impressed with prejudiced statements concerning "unused wastes." World War II has demonstrated the Soviet's claim to a position of world power. Soviet power, both potential and developed, is entirely invested in the great continental environment; Soviet weakness is in large measure its remoteness from the great ocean highway. The dual struggle of successfully occupying the land, the special goals of the post revolutionary five year plans, and finding suitable outlets to the sea have dominated the Soviet geopolitical structure.

The heart of the Soviet Union is a great triangle based on a line from Leningrad to Odessa, the western limits of the Union and the perennial zone of conflict between Slav and Teuton, and extending eastward to an apex near Lake Baikal in eastern Siberia. Here are the cities, the major railroad net out of which extends the Trans-Siberian, the wheat lands of the collectivist farms of Ukrania, the sugar beets, rye, flax and root crops of the central agricultural region, the old heavy industrial district of Donetz, and the new interior ones of Magnitagorsk and Kuznets. It is well to note that a comparable area in America would be in the latitude of Hudson Bay. Coal and iron and a great variety of other minerals are available in this district as well as in

widely scattered sections making the Union second only to the United States in these resources.

South of the internal triangle are the dry lands of the Caspian district, the Kirghiz Steppes and Turkestan Deserts, names no longer used. Here on the western shore of the Caspian and adjoining Caucasus is the leading petroleum district followed in importance by the Ural field. The petroleum reserves of the Soviet Union are as great as, if not greater than, those of the United States.

Northward stretch the two great zones of coniferous forest and Arctic coast, the Taiga and the Tundra, extending completely across the Union from Finland to the Pacific. Devoid of cities, uncultivated, and without railroads and roads the great north land is traversed by the Ob, Lena, and Enisei which flow northward to an ice-bound sea navigated under the greatest difficulty only during the short Arctic summer. The greatest distinction of the thinly forested northland is its great range of temperature. Winter averages of $-50°$ are common but official and unofficial reports of $-90°$ and $-100°$ from northeastern Siberia leave little to be imagined in severe winters.

To cross the great nation from east to west requires nine and one half days of continuous railroad travel, and it is over 5,000 miles between the farthermost points, yet there is no place in all the Soviet Union that possesses the portal characteristic of London or New York. With the frozen Arctic and Bering Seas to the north and east, the lofty plateaus and mountains of inner Asia to the south, and the smaller nations of middle Europe to the west, the Soviet Republics are well isolated from the rest of the world. It was this interior Asiatic land, partly in the Soviet Republics and partly in the plateau provinces of inner Asia whose rivers flow either into land-locked lakes and seas or the ice-bound Arctic and therefore are not accessible to seamen in their ships that Mackinder referred to as the, "heartland of the world island." It was this great continental fortress that Germany tried twice unsuccessfully to take, from which vantage point Eurasia and Africa might successfully be controlled on the way to ultimate world supremacy.

Strangely enough, the Russian nation has unceasingly tried to break out of the bounds of their imprisoning continental position. Arkhangelsk on the White Sea and Murmansk on the nearby Kola peninsula are the only acceptable escapes to the sea entirely unhampered by other nations. Peter the Great built

the "window-on-the Baltic" with its devious route through the Gulf of Finland, the German and Scandinavian waters of the narrow western Baltic and finally the North Sea. Catherine II provided the Black Sea route which could be blocked at innumerable places from the Bosporus to Gibraltar or Suez. Alexander II provided access to Vladivostok via the Trans-Siberian railway. The unfavorable position of Vladivostok on the Sea of Japan lead to the completion of the Chinese Eastern Railway in Manchuria to Port Arthur and eventually to war with Japan. The encircling lands to the south have offered other tempting routes of escape; across Iran to the head of the Persian Gulf, through Afghanistan, Mongolia, North China, or Tibet, all have met with difficulties; all have met with conflicting interest. Thus isolated in its continental position, the Russian nation escaped the economic, political, and social changes that took place in the states of Western Europe. World War I found Russia geopolitically youthful, incompletely and poorly developed in terms of use of earth resources. World War II found the Union of Socialist Soviet Republics attempting to crowd lost centuries of development into five year plans. Their attention seems now to be placed upon continentality—the complete and highest development of the state within its earth bound limitations.

United States of America

And now to the United States of America, young in years, mature in occupance, and based geopolitically upon a richly endowed continental area of 3,000,000 square miles, and a significant position in the major ocean routes of the world. From the one hundredth meridian eastward stretch a great variety of humid lands, the basis of a complex agricultural economy including such staples as cotton, corn, and wheat. Westward are the rough and dry lands dominated by dry farming, irrigation, and grazing. The great embayments to the heart of the continent furnished by the Great Lakes and the Gulf of Mexico, and the ample distribution of iron ore especially in the Superior upland, the coal of Appalachia, the widely distributed petroleum fields, and other earth resources have been extensively utilized in the development of the American national economy to the stage of maturity. The American state came to completion geopolitically in a very short space of time. After the initial barrier of the Appalachian highland was crossed,

American interest turned its back upon the sea and expended its whole energy in developing the nation. A continuous drive on the frontier carried the national structure westward until the United States became a great continental nation extending "from sea to shining sea." This continental growth was greatly accelerated by the development of the railroad. The great east-to-west railroad pattern today, augmented by highway and air routes, is one of the most distinguishing features of the completeness of geopolitical development. The dense pattern of cities and railroads in the north-east indicates the core around which the nation is crystalized. There are those who believe that the best of our natural resources are gone, the frontier is gone, that we can no longer skim the cream, and therefore we must either go down in living standards or into a complete socialized economy. This concept needs careful and exhaustive scrutiny. Although mature in the sense that an occupance pattern has been spread over the entire national area, the occupance features are far from a complete and stable integration—much maladjustment exists between natural resources and human usuage—in that sense the nation is still new and there is still much to be done. In comparison, the Soviet Union, though old in years is still pushing a Siberian frontier eastward and at the same time is wrestling with a gigantic technological frontier attempting to brings its occupance up to or above that of other leading nations, especially the United States.

The development of the interior, the interest in its factories, cities, farms, mines, forests, and the like, the land-minded portion of our national geographic personality, sometimes referred to as "isolationism," was of major concern during the inter-war years. World War II, however, demonstrated American significance in world affairs and focused attention upon the global phase of American geopolitical structure. Slowly the significance of the situation of the North American continent and the place of the United States thereon has been unfolding. Mackinder's geopolitical concept placed the landlocked areas of central Eurasia at the very center of world strategy with North and South America and Australia on the periphery. And thus it appears to be from the European point of view. Events, however, point to the fact that the United States likewise possesses a citadel position, a condition that gave rise to so-called isolationist policies and also permitted America to prepare for two wars while taking part in them. This advantage

might make the United States the initial victim of an attack with new and devastating weapons in the event of a third world war.

The importance of the American world position can be seen clearly only on the globe. In reality the United States not only partakes of both continental and oceanic geopolitical structure but actually occupies the key position in reference to both land based and sea based nations.

One of the most significant conditions of the arrangement of oceans and continents is the manner in which Eurasia and North America encircle the Arctic, with three great arms, South America, Africa, and Australia, extending southward well into the south hemisphere, the southerly most portion of which is the great uninhabited Antarctic land mass. Thus several oceanic basins result whose very shapes are the bases of the major world geopolitical patterns. The gigantic circular basin of the Pacific is the world's largest marine unit, and although shared by all three of the great powers, American position is strongest there. On the small North Atlantic basin on which American and British positions far outweigh the Soviet's, Britain is favored. The Indian Ocean, so long a British lake by virtue of the Mediterranean, Suez, and the Red Sea, has long been contested by land interests especially Germany and Russia. With the rise of air power, which has also augmented the strength of the above mentioned realms, a new zone, the Arctic basin, has assumed significance. All three of the major nations are here involved. "Over the pole to Europe" is grossly misleading, but it is well to note that the much publicized Kuznets basin of Siberia is some 8,000 miles from us directly over the North Pole.

These are the broad lines of post war geopolitical patterns. Within this frame work two opposing courses of action are available. Extreme competitive nationalism will lead to another World War; whereas, international understanding and cooperation will lead to world peace. America holds an especially good position to help shape geopolitical patterns along the lines of total peace.

An artificial eye, that moves in coordination with a person's good eye, is made of plastic with a mesh of tantalum metal covering its back portion. Mobility is obtained by sewing the eye muscles to the tantalum mesh. It can be implanted immediately after an injured eye is removed, or much later if desired.

THE MATHEMATICAL PROBLEM OF HIGH SCHOOL PHYSICS

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The amount and type of mathematics which should be included in the high school physics course is a fundamental question for the physics teacher to consider. An answer is given in the report of the Harvard Committee.[1]

Keeping in mind the necessity of linking mathematics and physics, let us approach the matter from another angle. We might start by observing that the high school physics group has usually elected the physics course because of pre-knowledge acquired at home, or guidance at the school, or by other contacts, for the direct purpose of college entrance, or for vocational ends. The high school group we find in physics is usually the stratum of higher intelligence. But what about the student who does not expect to attend college; for, does he find *use* or need for the mathematical content of the physics course? A report of the American Association for the Advancement of Science recently published in SCHOOL SCIENCE AND MATHEMATICS[2] states that only about 50% of the highest in intelligence of high school graduates attend college; the others prefer to enter occupations directly and make their own way. The value and practical applicability of the basic mathematical content of a physics course can be indicated, though roughly gauged, by a visit to the bookstore shelves whose books have been selected for popular sale. Here we find such titles as: *Mathematics for Everyday Life*, *Shop Problems in Mathematics*, *Mathematics for the Practical Engineer*, *Mathematics for the Power Plant Engineer*, *Simplified Home Study in Fraction, Ratio and Proportion, Etc.*, *Mathematics for Machinists*, *Shop Mathematics*, *Mathematics for Radiomen and Electricians*, *Mathematics and the Machinists Job*, *Vocational Mathematics*, *Mathematics for Flight*, and *Mathematics for Agricultural Science!* What could be more eloquent than this little jaunt from the ivory tower of academic discussion into this bookstore? In a workaday world where, in an environment that

[1] *General Education in a Free Society*, Report of the Harvard Committee, Harvard University Press, 1945, p. 152.

[2] "The Preparation of High School Science and Mathematics Teachers," Report No. 4. The AAAS Cooperative Committee on Science Teaching, SCHOOL SCIENCE AND MATHEMATICS, 2, pp. 107–118, February, 1946.

is attuned to industry based on the principles of physics, there is expressed a desire for the grounding in mathematics that the "traditional" course in physics offers, for such is the nature of the titles above. Certainly at this point we cannot fall back into quibbling over trivia of transfer of training or mental discipline or archaic theories of the value of mathematics courses; here we find suggested difficulties in the lives of flesh and blood people as they attempt to adjust themselves to realities of life in a mechanical age. Physics is definitely one answer to meeting the need here.

Thus does physics have other appeal than college entrance requirements. In fact, physics in high school becomes more important in many respects for the non-college entrant than for the college entrant; it might be his last chance for grounding in matters he is likely to have more direct contact with than the college graduate, on the level of the simpler applications he will be called upon to make as artisan, machinist, foreman, electrician, plumber, farmer, nurse, or in scores of other fields. Also the college student can get a thorough grounding in the physics type of mathematical technique in high school, especially if he enters a field requiring advanced courses in physics; for the greatest difficulty encountered in mastering college physics lies in the simpler elements of mathematical content the high school physics course should furnish, and which is included in the high school course. The points of greatest difficulty for the college student in physics peculiarly lie in the high school course, as will be shown by careful analysis of the college student's difficulties. This is the writer's own experience, also derived from observation while grading his own college students' papers in physics. At this point we might point ahead to a statement to be quoted, that science applications to mathematics (early algebra) do not assist in development of the purely mathematical technique in early algebra; for reasons to be pointed out, physics is the best place in the contemporary school set-up for the application of mathematics to technical fields, unless specialized technical courses are being offered by the high school.

In order to answer the question, how can physics with its mathematics content be effectively "put across" in the secondary school field, the writer wished to resort to academic authoritative sources, the purpose being to see if there were in the library books dealing with the psychology of the mathematics involved

in physics learning or teaching. The heads of the mathematics department and of the psychology department were consulted.

There was no such book. No one had heard of such a book.

Apparently neither psychology or mathematical philosophy books, many of which were examined, could give any account of a psychology of, or even remotely suggestive of, the situation encountered by a teacher and pupils who are confronted with necessity of dealing with the mathematics involved in physics.

Is it any wonder that the proposition is the grief of the administrator of schools, and the educational expert, not to speak of the technical instructor in the schools of engineering and of sciences on the college level? There were a few rather vague references which the writer decided had the germs of the problem, which are to be quoted.

The basic idea to be gleaned from the quotations below, is, that in physics problems, there are involved two distinct types of thinking. We shall notice distinctions made in types of mental processes involved in solving mathematical problems, both those purely mathematical, as well as those involving physics.

First we shall refer to the finding of G. E. Hawkins, University of Chicago High School, reported by Breslich.[3] The procedure followed was to search the science courses for science problems the beginners of algebra would later encounter, and teach algebra by using these problems. The result: "The science problems made little or no contribution to the teaching of mathematics. On the other hand, they actually added to the difficulty of algebra. The mathematical training derived from such problems was very small." It is definitely implied and proven here that learning algebra is a matter apart from its application to physics problems. This would further indicate that pure mathematics involves psychological processes entirely apart in their nature from the processes involved in application of mathematics to science. Evidently, mathematical thinking can best be developed apart from practical applications; on its own merits alone, before the technique of application is to be acquired. Thus it emerges, that the technique of applying mathematics to science problems has two psychologically separate sides, the mathematics side, and the mathematics-applied-to-science side. Granting this, we can further deduce

[3] Breslich, E. R., "Integration of Secondary-School Mathematics and Science," SCHOOL SCIENCE AND MATHEMATICS, 1, pp. 58–67, January, 1936.

for the purpose of hypothesis that there are probably two compartments of thought, separate and distinct,—two aspects of thought—two separate types of thought,—involved in science mathematical problems. Our next quotations will serve to suggest more definitely what constitutes the nature of the distinction between these two types of thought.

Brenda Lansdowne[4] draws a distinction between two definitions of mathematics. One definition holds that it is the science of quantity, number, and fundamental operations. Miss Lansdowne upholds the other definition, that mathematics is the science of *relationships*. Our purpose is not to settle a disagreement between mathematicians on how to define the subject, but to point out that Miss Landsowne does make a very significant observation of an aspect of thinking that appears at kindergarten age, before children she observed had learned "numbers" and how to count. As she states it, "children not able to count or perform any of the fundamental operations, yet perceived simple *relations* that were mathematical" in setting so many dishes, cookies, etc., to each place at lunch table. Here we see applied a distinction between the mental compartments involved in distinguishing relationships in which we have the ability to count and perform mathematical operations using "numbers." This distinction is very similar to that drawn in the preceding paragraph, and doubtless has the same basis.

We will find a closely associated thought by quoting Heiss, Obourn, and Hoffman, *Principles of Science Teaching*,[5] with reference to reading science texts; "In certain types of problems reading, however particularly those relating to special relationships in mathematics, a *vivid and well-trained* visual imagery is of great importance. It can be developed by 'verbal visualization,' in which pupils tell the exact space relationships and mental pictures which they see when reading passages in which these relationships are important, and by the use of imagery of all types in stimulating concentration while reading." Here we may notice that the perception of *relationships goes hand-in-hand with visual imagery;* and with *imagery of all types*. This imagery is one side of the two types of thought we are observing as involved in physics problems.

Now, in order to further define the basis of distinction be-

[4] Lansdowne, Brenda, "No Good at Math?" *Progressive Education Magazine*, p. 119, March, 1944.

[5] Heiss, Elwood D., Obourn, Ellsworth S., Hoffman, C. Wesley, *Modern Methods and Materials for Teaching Science*, The Macmillan Company, 1940.

tween our types of thought, we shall quote from Karl Duncker.[6] This work is highly recommended, is a translation from the German; it deals with problem solving purely from the standpoint of the psychologist. For our purpose we may quote a significant generalization made at the end of an involved discussion of a line crossing a certain triangle (!):

"With 'poor' mathematicians the thought material is from the very beginning more thoroughly imbued with perceptual functions of the sort described. (Note: the perceptual functions refer to models, not drawings.) For the 'good' mathematician, on the other hand, there remains a more abstract stratum into which all those functions, with their 'contrariness' to the recognition of other functions, do not reach; in other words, a stratum in which only the specific mathematical properties exist. . . . But how is it with many people the perceptual structurings dominate so excessively? Clearly, with them these perceptual structures play an indispensable role, more or less as do the visual images with people of the visual type. Just as the latter need visual images if anything is to be reached clearly and to be kept stably in mind, so many people appear unable to make their thought material precise, to survey it, and to keep it in stable form, unless it is 'fortified' and the core imbued with, such perceptual structuring."

Here there is implied a clear-cut distinction between abstract mathematical thought and visual imagery. There is suggested a bifurcation, two aspects, of thought, involved in mathematics and mathematical thinking. These two aspects of thought, one being fundamentally relational and based on imagery, the other highly abstract, and concerned with "pure" mathematics, present a familiar pattern to one who has experienced the teaching of the mathematics of physics. In physics problems, there are involved these two possibly separate phases of thought,—concept-formation of physical phenomena employing visual and other types of imagery (the "poor" mathematician may be rich in this capacity), and the "abstract stratum" of Karl Duncker involving purely mathematical symbolism, numbers, operations. In passing, it may be observed that the "good mathematician," who has practiced the withdrawal into his "abstract stratum," finds it difficult to retain for purposes of solving physics problems the necessary "perceptual structurings" (or concepts of physical phenomena); the writer has often noticed that in his own physics classes the students who are considered "crack" students in mathematics as often as not find difficulty with the *imagery of physics concepts*. The good

[6] Duncker, Karl, "On Problem Solving," translated by Lynne S. Lees in *Psychological Monographs*, John R. Dashiell, Editor, Vol. 58, No. 5, 1945. Published by the American Psychological Association, Inc., Northwestern University Press. See p. 110, near the end of the chapter "On Functional Fixedness of Mathematical Solution-Elements."

student in mathematics finds to his dismay and consternation that mathematical facility does not carry him over when he strikes his physics problems, that it "takes something he does not readily have," but which must, and can be *developed* . . . . We might assume with Duncker that the above conditions determine the basis of differentiating the two extreme types of mathematicians, good and poor; we might observe that "some people" are rich in conceptual-imagery capacity, others in ability to withdraw into an abstract stratum; if we assume that there are many intermediate grades, with different degrees of balance between the two extreme types of thought being suggested herein, we shall probably be considering the majority, who rate an average norm. If the above premises are valid, we may safely conclude that in the job of physics teaching of problems, we are *dealing with two capacities of mind;* and most important of all either of these capacities may be developed and is best developed separately, apart, and after development, integrated and coordinated. In other words a physics problem presented to a class of students may most effectively be given a triple treatment; first, that the conceptual and imagery aspects be clearly presented and worked over; second, that there be given a separate treatment of the purely mathematical aspects involving mathematical operations; third, that each of these two aspects be subjected to another treatment in which they are coordinated in the thinking of the class, especially in the earlier stages.

The task of teaching the mathematics of physics, then, would be:

1. Developing these two capacities (concept-forming and concept-retaining, mathematical operation) *as two separate functions.*

2. *Relating* these two capacities by careful, patient training of the student to operate the capacities simultaneously, in a process of build-up. In working his problems, he integrates his concepts in physics; when he learns to integrate concepts of physical phenomena mathematically, he has acquired *scientific method* of the most fruitful sort, he knows physics; and can measure the distance to the stars for himself.

The writer has never had a teacher who seemed to realize the need of the above approach, or possibilities for *building* the mathematical capacity for working the problems of physics. In his teaching, he has found his efforts in this regard exceedingly

fruitful. In order to test the method, he once taught through mechanics using no textbook at all, but furnishing mimeographed problems as the students entered class. The problems were selected on the "build-up" plan. Principles involved were demonstrated in class, then the problems were worked as a group exercise, led by the teacher. Ample time was taken. Tests showed, at the ends of the six-weeks periods that the students retained the capacity to do a well above the average job of working physics problems carefully selected to reveal the understanding of basic principles of mechanics. The student interest was keen.

Ignoring the possibility and necessity of a build-up along the above lines, (two lines) the general policy has been an insistence upon throwing the student into a scientific jam to let him work himself out in the matter of acquiring physics-mathematics technique. It is no wonder at all that physics in high schools has become regarded as an occasion for mental indigestion. When carefully inducted into the mathematical side of physics, the student gains momentum in capacity. The student,—even the best of High School mathematics students,—must *acquire the technique*,—not have it thrown at him. The "intuition" of mathematics which has stood the student well in algebra, geometry, trigonometry, if depended on in physics usually gets the student into a muddle, from which he often cannot extricate himself. The problems are often assigned him to work "if he can." Too often the joker is, of course, he cannot. One or two bright students may do them. The rest of the class is considered mentally below par, incapable of being taught. Students elect other courses, the "crip" courses. The principal shakes his head sadly and knowingly, and decides it is the best "policy" to keep himself out of the struggle. He languidly decides there must be something wrong with physics, it must be out of step with educational philosophy, or maybe with the demands of democracy.

3. Problems are to be taught with the view in mind of also *using them to teach physics by*, as well as to build mathematical capacity. They furnish an important *teaching vehicle* for *integrating concepts* of physics. Thus the physics problem, while it is being taught as a technique in itself, becomes a tool of teaching; it can be a great help in clarifying, even imparting concepts, a method of *defining* concepts, of *classifying* concepts

and finally, it provides a channel for *using* concepts. It becomes a *vehicle of coordination* of brain centers.

Of course, this does not imply that the problems alone are to be depended upon, the whole process involves also concept-formation from direct observation of demonstrations, of experiments in the laboratory, and of careful presentation by the teacher or textbook.

4. Recognize that the ability is not native, but acquired, that it is acquired by a process of "build-up," from both sides, or both aspects, of thought involved; then by integration *and coordination* of what are two originally separate compartments of intellectual activity.

5. Observe certain points of contact between the act of concept-formation, and the use of mathematics. The following points are suggested for consideration and interrelation:

a. For the purposes of the first stages of concept-formation, the teacher may employ laboratory, or demonstration, or diagramming figures, or discussion or a mathematics problem or a textbook assignment, or a combination.

b. Express the concepts formed in mathematical statement, where required.

c. Point out mathematical concepts of relationships, or relationships expressed mathematically.

d. Integrate concepts and relationships through mathematical devices.

e. Express findings in formulas.

f. Use the formula in similar situations, and a variety of situations. This is not suggested as an order of methodology, but as different aspects of patterns that vary with different situations.

g. Simultaneousness of presentation helps us here; we apply simultaneousness to link the functions of ***relationship—mathematical relationship—with mathematical procedures.***

As example: a/b is a relation between a and b, so is $a \times b$, and a varies with b. Power equals work/time is a relation, as is P_1/P_2 equals V_2/V_1. The first step is to teach the student to perceive or conceive the relation, he forms the concept; *simultaneously* the concept is expressed in the formula. After this is really accomplished, it is inane to presume that he will not pursue with zest and fascination the application of formulas to such situations as those involving the distance a car with a given

weight and speed will go when the brakes are applied with a given force, or the possible speed of an airplane whose propeller horsepower delivery is so much when an engine of given horsepower drives it.

6. Make allowance for distinction between *learning* and *performing* such mathematical processes. Certainly they can be *taught*, and we may rest assured that the student cannot do them until he has been taught. They can be taught without violating any valid rule or philosophy of education.

TO SUMMARIZE: The physics situation demands a thorough reconsideration by the administrator and by the curriculum expert, both of whom are not generally familiar with the aims and objectives of, and purposes served by, the physics course. These need to be restated in form acceptable to, and understood by those entrusted with the task of guiding the high school youngster.

More vital techniques of presentation of physics need to be worked out, and stated in terms adaptable by the teacher of physics to the high school student. The problem of handling the mathematics of physics requires more and careful attention, rather than being brushed aside. The high school course should definitely build a foundation of mathematical ability.

A MOBILE CLINIC FOR EYE CARE

America's first mobile clinic for providing eye care in remote areas was dedicated at Trenton Oct. 12, in ceremonies at the state capital.

Taking part in the unveiling of the nation's first eye clinic on wheels will be Gov. Walter E. Edge, of New Jersey, members of the New Jersey Commission for the Blind, and state public health and welfare officials. Dedication of the two and one-half-ton unit, sponsored by the New Jersey commission which has pioneered in bringing eye care to the needy in sparsely settled areas of the state, will be held on the capital grounds at noon.

Nineteen feet long and more than six feet wide, the unit contains Bausch & Lomb Optical Company equipment, including a refracting chair, refractor, slit lamp, and such diagnostic equipment as retinoscopes and ophthalmoscopes found in the unit's modern eye examining room.

The Rochester, N. Y., optical firm planned the interior layout so that the many delicate instruments used in eye examinations could be safely transported to rural areas for immediate clinical diagnosis of eye conditions.

Diagnosis of eye diseases, minor treatments and operations along with examination of eyes for glasses can thus be made readily available in all areas.

Somewhat similar to the mobile optical units used overseas during the war by the armed forces, the rolling eye clinic will provide a public health service rivaling that of the mobile hospital clinics now in use in the south.

ILLUSTRATIONS OF THE VERSATILITY OF THE BINOMIAL THEOREM

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The purpose of this note is to present a summary of the more important applications of the binomial theorem which do not require more than a knowledge of elementary algebra. It is believed that this material may be utilized as a basis for several lectures and discussions in mathematical clubs and in college algebra courses. For the sake of brevity the proofs which can be found in standard textbooks have been omitted. The proof presented in section 5 does not fall within this category. For the purposes at hand the author devised a special proof which can be understood by a student of the usual advanced or college algebra course.

1. *Notations.*—Throughout this article the following notations will be used:

u_x denotes the value of the function

$$u=f(y), \quad \text{for} \quad y=x \tag{1.1}$$

$$\Delta u_x=u_{x+1}-u_x \tag{1.2}$$

$$\Delta^k u_x=\Delta^{k-1}u_{x+1}-\Delta^{k-1}u_x \tag{1.3}$$

$$n!=1\cdot 2\cdot\cdots\cdot(n-1)n \tag{1.4}$$

$$n^{(k)}=n(n-1)\cdot\cdots\cdot(n-k+1)=\frac{n!}{(n-k)!} \tag{1.5}$$

$$n_{(k)}=\frac{n^{(k)}}{k!} \tag{1.6}$$

2. *Elementary algebra.*—In its simplest form, when the exponent is a natural number, the expansion of the binomial may be conveniently written as

$$(a+b)^n=\sum_{x=0}^{n} n_{(x)}a^{n-x}b^x \tag{2.1}$$

remembering that $n_{(0)}=n_{(n)}=1$.

When n is a fraction or a negative integer the expansion of a binomial of the type $(1\pm x)^n$ will give an infinite power series which will be convergent only for $-1<x<1$. A few examples will illustrate the principles involved.

Examples:

$$1+2x+3x^2+\cdots=(1-x)^{-2} \tag{2.1}$$

$$1+\tfrac{1}{2}x+\frac{1\cdot 3}{2^2\cdot 2!}x^2+\frac{1\cdot 3\cdot 5}{2^3\cdot 3!}x^3+\cdots=(1-x)^{-1/2} \tag{2.2}$$

$$1+\tfrac{1}{4}x-\frac{1\cdot 3}{4^2\cdot 2!}x^2+\frac{1\cdot 3\cdot 7}{4^3\cdot 3!}x^3-\cdots=(1+x)^{1/4}. \tag{2.3}$$

The expansions shown above are permissible only for $-1<x<1$.

$$\sqrt{7}=(9-2)^{1/2}=3\left(1-\frac{2}{9}\right)^{1/2}$$

$$=3\left[1+\frac{1}{9}-\frac{1\cdot 1}{9^2\cdot 2!}+\frac{1\cdot 1\cdot 3}{9^3\cdot 3!}-\frac{1\cdot 1\cdot 3\cdot 5}{9^4\cdot 4!}+\cdots\right] \tag{2.4}$$

$$\sqrt[5]{23}=(32-9)^{1/5}=2\left(1-\frac{9}{32}\right)^{1/5}$$

$$=2\left[1+\frac{1}{5}\cdot\left(\frac{9}{32}\right)-\frac{1\cdot 4}{5^2\cdot 2!}\cdot\left(\frac{9}{32}\right)^2+\frac{1\cdot 4\cdot 9}{5^3\cdot 3!}\cdot\left(\frac{9}{32}\right)^3-\cdots\right]. \tag{2.5}$$

Examples (2.1), (2.2), and (2.3) show that certain power series which appear rather complicated are really expansions of a binomial. As far as examples (2.4) and (2.5) go, they show that the binomial theorem can be applied to any radical and the use of logarithms is not absolutely necessary for the determination of the approximate value of an irrational number. In fact, the use of the binomial series places no restriction upon the number of significant figures that can be computed while the use of logarithms automatically limits them to the number of places shown in the table.

3. *Theory of probability.*—If the probability of success in any one trial is p then the probability of k successes in n independent trials is $n_{(k)}\ p^k\ q^{n-k}$ where $q=1-p$ is the probability of failure.

Example (3.1)

Q. What is the probability of obtaining 12 heads in 20 tosses of a coin?

A. Here $p=q=\frac{1}{2}$. The required probability is given by the

term containing p^{12} in the expansion of the binomial $(p+q)^{20}$ or by $20_{(12)}p^{12}q^8$, which equals

$$\frac{20!}{8!12!}\cdot\frac{1}{2^{20}}.$$

A sufficiently close approximation may be obtained by the well known Stirling formula

$$n!=\sqrt{2\pi}\,n^{n+1/2}e^{-n}.$$

Thus,

$$\log 20!=\tfrac{1}{2}\log 2+\tfrac{1}{2}\log\pi+20.5\log 20-20\log e$$
$$=18.38430$$
$$\log 8!=4.60552$$
$$\log 12!=8.68034$$
$$\log 2^{20}=6.02060$$
$$\log\{20_{(12)}p^{12}q^8\}=9.07784-10.$$

The required probability equals .12 approximately.

Example (3.2)

Q. What is the probability of obtaining 7 or 11 in a single throw of 2 dice?

A. In this case use can be made of the multinomial expansion. In one throw of a single dice the numbers 1 to 6 are equally likely to appear. Thus, according to the theory of probability the probability of throwing 7 is given by 1/36th of the coefficient of x^7 in the expansion of $(x+x^2+x^3+x^4+x^5+x^6)^2$ which is 6. Similarly, the probability of throwing 11 is 1/36th of the coefficient of x^{11} which is 2. Thus, the total probability is

$$\frac{6}{36}+\frac{2}{36}=\frac{2}{9}.$$

4. *Finite differences.*—In the calculus of finite differences the binomial theorem is frequently applied to operators. An idea of the procedure involved may be obtained from the following examples.

Example (4.1)

Q. Given 4 ordinates of a third degree polynomial $u_5=15$, $u_6=50$, $u_7=95$, and $u_8=200$, find the algebraic form of the polynomial.

A. The work may be arranged as follows:

x	u_x	Δu_x	$\Delta^2 u_x$	$\Delta^3 u_x$
5	15	35	10	60
6	50	45	70	
7	95	115		
8	210			

Now

$$u_x = u_{5+(x-5)} = (1+\Delta)^{x-5}u_5$$

$$= u_5 + (x-5)\Delta u_5 + \frac{(x-5)(x-6)}{2!}\Delta^2 u_5$$

$$+ \frac{(x-5)(x-6)(x-7)}{3!}\Delta^3 u_5$$

$$= 15 + 35(x-5) + 5(x-5)(x-6) + 10(x-5)(x-6)(x-7)$$

$$= 10x^3 - 175x^2 + 1050x - 2110.$$

This method is much less laborious than the solution of 4 linear equations involving the 4 unknown coefficients of the assumed polynomial

$$u_x = ax^3 + bx^2 + cx + d.$$

Example (4.3)

Q. Given the same values as in example (4.3) compute u_1 without finding the coefficients of the polynomial.

A. Here again we use the table of differences and the expansion for u_x which in this particular case will be

$$u_1 = (1+\Delta)^{-4}u_5 = u_5 - 4\Delta u_5 + 10\Delta^2 u_5 - 20\Delta^3 u_5$$

$$= 15 - 4 \cdot 35 + 10 \cdot 10 - 20 \cdot 60 = -1225.$$

5. *Hypergeometric series.*—We come now to an interesting extension of the binomial theorem to series involving factorial powers $x^{(k)}$ instead of the ordinary powers x^k. As stated in the introduction, the proof presented here has the advantage of not requiring the use of mathematics beyond elementary algebra.

Theorem: For any positive integral values of a, b, and n

$$(a+b)^{(n)} = \sum_{x=0}^{n} n_{(x)} a^{(n-x)} b^{(x)}. \tag{5.1}$$

Proof: We shall prove (5.1) by induction. For $n=1$, the expansion obviously holds true since $n_{(0)}=n_{(1)}=1$. It remains to show that if (5.1) holds for $n=1, 2, \ldots, k$ it must also be true for $n=k+1$. In fact,

$$\begin{aligned}(a+b)^{(k+1)} &= (a+b)^{(k)}\cdot(a+b-k)\\ &= a^{(k)}(a-k)+a^{(k)}b\\ &\quad +k_{(1)}a^{(k-1)}(a-k+1)b+k_{(1)}a^{(k-1)}b(b-1)\\ &\quad +k_{(2)}a^{(k-2)}(a-k+2)b^{(2)}+k_{(2)}a^{(k-2)}b^{(2)}(b-2)\\ &\quad +\cdots\\ &\quad +k_{(k)}ab^{(k)}+k_{(k)}b^{(k)}(b-k). \qquad (5.2)\end{aligned}$$

Combining the second term of each line of (5.2) with the first term of the preceding line we obtain expressions of the type

$$\begin{aligned}&k_{(r-1)}a^{(k-r-1)}b^{(r-1)}(b-r+1)+k_{(r)}a^{(k-r)}(a-k+r)b^{(r)}\\ &\quad =\left[k_{(r-1)}+k_{(r)}\right]a^{(k+1-r)}b^{(r)}\\ &\quad =(k+1)_{(r)}a^{(k+1-r)}b^{(r)} \qquad \text{since} \qquad (5.3)\end{aligned}$$

$$\begin{aligned}k_{(r-1)}+k_{(r)} &= \frac{k!}{(k-r+1)!(r-1)!}+\frac{k!}{(k-r)!r!}\\ &= \frac{k!}{(k-r)!(r-1)!}\left(\frac{1}{k-r+1}+\frac{1}{r}\right)\\ &= \frac{k!(k+1)}{[(k-r)!(k-r+1)][(r-1)!r]}\\ &= \frac{(k+1)!}{(k+1-r)!r}=(k+1)_{(r)}.\end{aligned}$$

Thus, utilizing (5.3), the expansion (5.2) may be written as

$$\begin{aligned}(a+b)^{(k+1)} &= a^{(k+1)}+(k+1)_{(1)}a^{(k)}b+(k+1)_{(2)}a^{(k-1)}b^{(2)}\\ &\quad +\cdots+b^{(k+1)}\end{aligned}$$

which proves the theorem.

Example (5.4)

Q. An ordinary deck of cards contains 26 black and 26 red cards. Six cards are drawn singly without replacement. What is the probability that of the cards drawn 4 will be black?

A. The probability of drawing k black cards in n trials is given by the term containing $b^{(k)}$ in the expansion of

$$\frac{(b+r)^{(n)}}{N^{(n)}}$$

where $b+r=N$. In this case, $N=52$, $b=r=26$, and $n=6$. Thus the required probability equals

$$\frac{6_{(2)}\cdot 26^{(4)}\cdot 26^{(2)}}{52^{(6)}}=\frac{6\cdot 5}{2}\cdot\frac{(26\cdot 25\cdot 24\cdot 23)(26\cdot 25)}{52\cdot 51\cdot 50\cdot 49\cdot 48\cdot 47}$$

$$=\frac{37375}{156604}=.24 \text{ approximately.}$$

Example (5.5)

Q. Assuming the conditions of example (5.4) what is the probability that 3 black and 3 red cards will be drawn?

A. Proceeding as in (5.4) we find that the required probability equals

$$\frac{6_{(3)}\cdot 26^{(3)}\cdot 26^{(3)}}{52^{(6)}}=\frac{13000}{39151}=.33 \text{ approximately.}$$

REFERENCES

Hall, H. S., and Knight, S. R., *Higher Algebra*, Macmillan Co., New York.
Freeman, Harry, *Mathematics for Actuarial Students*, Vol. II, Cambridge University, Press, 1939.
Aitken, A. C., *Statistical Mathematics*, Oliver and Boyd, 1939.

WAYNE G. NORTON RECEIVES THE ADOLPH LOMB MEDAL

In recognition of war research on fire-control instruments for better marksmanship in shooting down enemy aircraft, 27-year-old Wayne G. Norton of the Eastman Kodak Company, Rochester, received the Adolph Lomb medal from the Optical Society of America Friday evening, Oct 4, at the Society's thirty-first annual meeting.

The award is made annually "to a person under 30 years of age who shall have made a noteworthy contribution to optics" according to Dr. Arthur C. Hardy, Massachusetts Institute of Technology physicist who is secretary of the Society. It was made possible by a fund left by Adolph Lomb who was treasurer of the Society from its founding until his death in 1932.

Mr. Norton was born in Chicago, attended high school in Evanston, Ill., and was graduated from the University of Rochester in 1941. He has been employed by the Eastman Kodak Company since 1941 and during the war he engaged in production engineering, research, design and development of fire-control instruments, including the heightfinder and rangefinder, produced for the army and navy.

A STUDY OF ALTERNATING CURRENT FREQUENCY

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By making use of the apparatus available in the average science laboratory, it is possible to measure the frequency of the local alternating current and to demonstrate the application of the rotating mirror and the stroboscope. These experiments may be done in the classroom as demonstrations or may be assigned as individual problems, including the making of a stroboscopic disk from a sheet of heavy cardboard or thin metal. The disk employed here has 36 slots and a diameter of 2 feet. Care should be taken to space the slots evenly. The equipment requires a variable speed rotator (a Cenco rotator is used) with a revolution counter, a stop clock, a four (or more) sided mirror, stroboscopic disk and neon bulb (see Fig. 1).

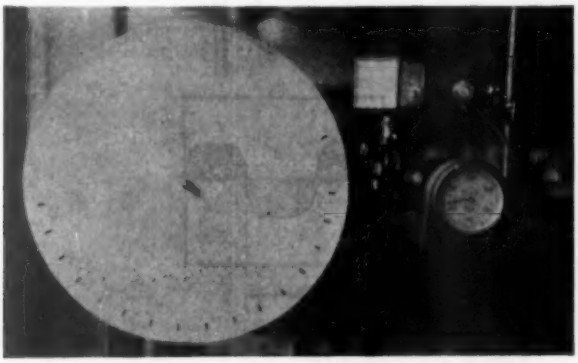

FIG. 1. Apparatus used in the experiment.

When a 2-w neon bulb is connected to the 60 cyc/sec power supply, each semi-circular segment is alternately bright and then dark for approximately 1/120 th of a second. When viewed directly, this occurs so rapidly that both segments appear to glow continuously. When the neon bulb is viewed in a rotating mirror (see Fig. 2), the fact that the segments glow alternately is very clearly demonstrated. The length of each bright segment or the number of segments which appear in the field of vision depends upon the speed of rotation of the mirror. It is interesting to raise with the student the question as to whether or not

the pattern depends upon the number of faces of the rotating mirror. He may check his conclusion easily by merely covering with black paper some of the faces.

The frequency of the alternating current may be determined directly from observations made through a telescope containing a reticle or by use of a camera. In Fig. 3, N represents the neon bulb, M the rotating mirror, L the lens of the telescope or camera and w the width of a bright segment (refer to Fig. 2) as measured on the reticle or photographic plate P. The mathematically inclined student will have no difficulty in deriving an expression for the time t which elapses as the rotating mirror

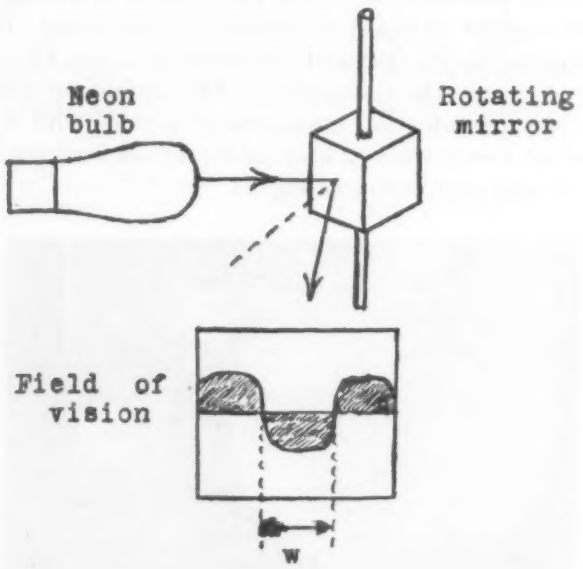

FIG. 2. Neon bulb viewed in a rotating mirror.

pulls the image of the glowing segment a distance w across the field of vision. This method of measurement was used by Professor R. J. Stephenson of the College of Wooster and the author in a study of manometric flames[1] and it was shown that $t=w(b+a)/2\omega ac$ where a, b and c represent the distances indicated in Fig. 3 and ω represents the speed of rotation of the mirror.

The frequency of the AC power supply may be determined without the use of a rotating mirror. The stroboscopic disk is

[1] R. J. Stephenson and G. K. Schoepfle, *American Journal of Physics*. 14, 294 (1946).

mounted on the variable speed rotator and the speed adjusted until one segment of the neon bulb glows continuously when viewed directly through the slots of the rotating disk. For a proper adjustment of the rotational speed of the disk the bulb is viewed periodically at only those instants when either segment is bright. The frequency is computed from a knowledge of the number of slots in the disk and the speed of the rotator and this frequency is checked against the number of cycles per second for the AC power supply employed. Again several questions present themselves, such as to whether or not a series of

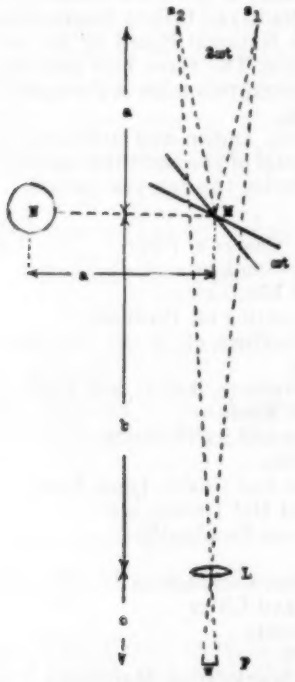

FIG. 3. Drawing representing the images s_1 and s_2 of the bulb in the rotating mirror and their images on the photographic plate.

speeds for the rotator is possible and the affect of the diameter of the stroboscopic disk. The student may check his answers by actual experiment. If another rotator is available, the moving pattern reflected from a rotating mirror may be brought to rest when viewed through the slots of the rotating stroboscopic disk adjusted for the proper speed.

These experiments with simple equipment may be adapted

to short classroom demonstrations or may be expanded into longer projects for individual students with experimental, mathematical or photographic inclinations. Some questions which the student may answer for himself by direct experiment are suggested and other questions and possibilities will suggest themselves to the reader.

WHAT CAUSES DESTRUCTIVE FIRES?

Matches and smoking caused 29.44 per cent of all fires in claims reported to the National Board of Fire Underwriters in the ten-year period from January 1, 1935 to January 1, 1945. The following figures do not represent the total number of fires in the United States since they cover only those claims reported to the National Board by its member companies where the cause is ascertainable. The many fires resulting from unknown causes are not included. However, this table is the most comprehensive study of causes of fires available.

Fires, from all causes, known and unknown, insured or not insured, reached an estimated total of two and three-quarter billion dollars' damage in the United States during this ten-year period.

Reported Cases	*Causes of Fires*	*Per cent of Causes*	*Per cent Property Loss*
1,005,576	Matches—Smoking	29.44	16.43
351,152	Misuse of Electricity	10.28	9.57
264,320	Fire Originating off Premises	7.74	12.80
237,930	Chimneys, Flues, etc.	6.96	8.81
232,063	Lightning	6.79	4.83
213,798	Stoves, Furnaces, Boilers, and Pipes	6.26	8.97
212,773	Sparks on Roofs	6.23	5.18
202,179	Petroleum and its Products	5.92	7.49
190,388	Open Lights	5.57	2.24
143,641	Hot Ashes and Coals—Open Fires	4.20	2.20
102,799	Ignition of Hot Grease, etc.	3.01	1.71
60,474	Spontaneous Combustion	1.77	7.96
48,543	Gas	1.42	1.46
33,359	Sparks from Combustion	.98	2.37
29,721	Rubbish and Litter	.87	.82
26,142	Miscellaneous	.77	1.85
25,895	Explosions	.76	2.41
24,902	Friction, Sparks from Machinery	.73	2.75
10,395	Fireworks, Balloons, etc.	.30	.15
3,416,050		100.00	100.00

5000-YEAR-OLD FISH TRAPS

Tidal fish-traps, used today in some sections of the South African coast, were built as many as 5000 or 6000 years ago. These dams on the beach consist essentially of stone enclosures built high enough to be covered at normal high tide so that fish can swim freely over them. As the tide sinks. however, water runs out through the chinks between the stones, but the fish are trapped. They can then be clubbed or caught by hand.

THE ELEMENTARY SCHOOL SCIENCE LIBRARY FOR 1945–1946

PAUL E. KAMBLY

University of Oregon, School of Education, Eugene, Oregon

This third list of reference books for elementary school science includes books published during the past school year, books recently reissued and some books that were overlooked in previous listings.[1]

The grade levels indicated are the lowest recommended by the compiler. The annotations are included as aids in determining the possible usefulness of the references in supplementing a science program. List prices are recorded and are, of course, subject to change. The subject matter divisions are used only as a convenient means of grouping the references included in the list.

REFERENCE BOOKS FOR ELEMENTARY SCHOOL SCIENCE

Ancient Animals

	Gr.	Price
Early Man and the Animals. By Wilhelmina Slootmacher. 36 pp. '46. Merrill*	2	.20

A unit book with teaching aids. An imaginary story of Kim and Kee who lived in a cave home. Illustrations in black and white.

Animals

(See also book on insects)

Hermie's Trailer House. By M.L. Guberlet. 32 pp. '46. Cattell	1	1.25

The story of a hermit crab. Hermie talks, falls in love and gets married but there is also good information about crabs.

How Animals Travel. By Frances Everhart and Mae McCrory. 36 pp. '46. Merrill	1	.20

A unit book with teaching aids. Illustrations in black and white.

Animals Work, Too. By A. I. Gates and Mary McClenaghan. 48 pp. '40. Macmillan	2	.24

[1] Kambly, Paul E.: "The Elementary School Science Library," SCHOOL SCIENCE AND MATHEMATICS, 44: 756–767. November, 1944. "The Elementary School Science Library for 1944–1945." SCHOOL SCIENCE AND MATHEMATICS, 46: 13–16. January, 1946.

* Publishers and their addresses are listed at the end of this section.

	Gr.	Price
The activities of certain birds and ants. A reader.		
Elephants. By H. S. Zim. 62 pp. '46. Morrow.....	2	2.00
All about elephants. Very well illustrated.		
Life in the Sea. By E. M. Johnson. 36 pp. '46. Merrill.....	2	.20
A unit book with teaching aids. Includes lobsters, clams, oysters, crabs, turtles, jellyfish, whales, sharks, sponges and the octopus. Illustrations in black and white.		
Where Animals Live. By Mae McCrory. 36 pp. '46. Merrill.....	2	.20
A unit book with teaching aids. Animals live in the jungle, on the desert, in cold lands, in your neighborhood, in the water and under the ground. Illustrations in black and white.		
Trails in the Woods. By A. I. Gates, A. K. Liveright and Irene Esterline. 48 pp. '40. Macmillan.....	3	.24
Includes stories about wrens, squirrels, skunks and possums. A reader.		
What Animals Eat. By Frances Lacy. 36 pp. '46. Merrill.....	3	.20
A unit book with teaching aids. Nectar, sap, seeds, insects, other animals, and plant parts. Illustrations in black and white.		
South American Zoo. By Victor Von Hagen. 182 pp. '46. Messner.....	5	2.50
Unusual animals of South America in their natural homes.		
Jungle Animals. By Frank Buck. 56 pp. '45. Random.....	6	1.00
A colorful encyclopaedia of jungle animals.		
Astronomy		
Sun, Moon and Stars. By Jeanette Smith. 36 pp. '46. Merrill.....	2	.20
A unit book with teaching aids. Emphasis on the constellations. Illustrations in black and white.		
Sun, Moon and Stars. By W. T. Skilling and R. S. Richardson. 274 pp. '46. Whittlesey.....	5	2.50
An excellent reference book for good readers.		
Astronomy. By J. S. Allen. 199 pp. '45. Bobbs....	6	2.50

Gr. Price

Contains the usual information with numerous illustrations.

Foods of Man

Grapes. By Pennsylvania Writers' Project. 46 pp. '45. Whitman ..... 4 .50

Culture, propagation, diseases, harvesting and uses.

Indian Harvest. By J. M. Lucas. 118 pp. '45 Lippincott 6 2.00

This book on the wild food plants of America is written for the layman. It is clearly written and is an excellent teacher reference for "Indian Units" at any grade level. Beautifully illustrated in both black and white and color.

General Nature Study

Protection in Nature. By Gaynelle Davis. 36 pp. '46. Merrill ..... 3 .20

A unit book with teaching aids. Includes color, fighting, poisons, quills, odors, locomotion, homes, tricks, cooperation and how plants protect themselves. Illustrations in black and white.

Chukchi Hunter. By Dorothy Stall. 224 pp. '46. Morrow 5 2.00

An interesting story of Ankat who is a Chukchi boy living on top of the world on the eastern tip of Siberia. A good reference on animals and living conditions of the arctic.

The Ocean Book. By J. Y. Beaty. 240 pp. '46. Beckley 5 1.35

Interesting accounts of starfishes, fiddler crabs, sea horses and other animals. Also describes plant life, tides, currents and waves. Well illustrated.

General Science

Let's Find Out. By Herman and Nina Schneider. 38 pp. '46 Scott 1 1.25

Some of the questions answered are:
Why does a teakettle sing?
Why does it rain?
Why does a metal doorknob feel colder than the wooden door?
Why does an airplane stay up?

Simple Machines. By Jeanette Smith. 36 pp. 46. Merrill ..... 2 .20

	Gr.	Price
A unit book with teaching aids. Wheels, levers, wedges, inclined planes, screws and pulleys. Illustrations in black and white.		
Making the Movies. By Jeanne Bendick. 190 pp. '45. Whittlesey	5	2.00
A complete story of movie making including some history. Well written and entertainingly illustrated.		
An Open Door to Chemistry. By J. L. Horning and G. C. McGinnis. 86 pp. '46. Appleton	6	2.00
Acids, bases and salts; oxidation and reduction; chemtry of food; water; commercial and industrial chemistry; indicators.		
Sound. By M. K. Chapin. 32 pp. '46. Merrill	6	.20
A unit book with teaching aids. Illustrations in black and white.		
Insects		
Bees and Ants. By R. G. Strickland. 36 pp. '46 Merrill	4	.20
A unit book with teaching aids. Illustrations in black and white.		
Plants		
Up Above and Down Below. By I. E. Webber. 32 pp. '43. Scott	1	1.25
Simple book about plants for young readers. Page size drawings, in color, with captions that complete the story.		
Travelers All. By I. E. Webber. 32 pp. '44 Scott	2	1.25
This small beautifully and accurately illustrated book tells how plants go places.		
Our Trees—How to Know Them. By A. I. Emerson and C. M. Weed. 295 pp. '36. Lippincott	6	3.00
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TEACHERS PAID LESS THAN MILKMEN TRAIN YOUNG AMERICA FOR ATOMIC AGE

American youth cannot be properly educated for an atomic age until high school science teachers are paid higher salaries than janitors and milkmen, according to Dr. Paul E. Klopsteg, chairman of the American Institute of Physics.

"Teacher salaries have advanced little in recent years, while incomes in other occupations have risen by leaps and bounds," he said.

"The discrepancy between teacher salaries and incomes in other occupations is much wider in the United States than in other countries. This means that there is less incentive, relatively, for the best brains to enter teaching in the United States than in other countries. We cannot hope to retain or advance our scientific superiority in the dawning atomic age unless this weakness in our society is overcome.

"Financially there is more incentive for a young man to seek to meet the requirements to become a metropolitan milkman or apartment building janitor than to train himself for a career in high school science teaching."

Recent surveys, Dr. Klopsteg said, have shown that the average teacher salary is about $1500 a year, and most high school teachers receive less than $2000. Many milk deliverers receive more than twice as much in wages and commissions, he said. Factory wages have long been higher than teacher salaries, he added.

Dr. Klopsteg, who is director of the Technological Institute of Northwestern University, said that there will be a critical shortage of scientist and science teachers for many years, because the demand is increasing while thousands of young men who would normally have become scientists have been diverted from their careers or have lost several years of education during the war.

"Improvement of high school science teaching is imperative for two major reasons," Dr. Klopsteg said.

"It is at the high school level that exceptional youths should be inspired to take up science as a career. This objective cannot be achieved by indifferent teaching.

"Some familiarity with science is basic to good citizenship and proper appreciation of our modern civilization. High school is the place to acquire this.

"Teaching standards must be raised to meet modern needs, but better teaching requires higher salaries."

CHANGE OF BASE

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Occasionally some one writes an article or pamphlet attempting to show why a number system on base 8 or 12 is more convenient than the common number system on base 10. Theoretically their arguments are good, particularly with respect to base 12, since 12 is a multiple of more numbers than 8 or 10 and hence will accommodate more convenient fractional parts of units or groups. Eight is better than 10 because halves, fourths, and eighths meet more practical applications in daily life than halves, fifths and tenths, say the advocates for base 8. The disadvantage of base 8 will appear later in this article.

A glance at the history of mathematics, man in the primitive age, and human anatomy readily reveal why counting on many and diverse bases existed. Before there was a number system man counted the sheep in his flock or the cattle in his herd by means of a sort of one-to-one correspondence method. The keeper of the animals gathered a pile of stones and placed them at the gate of his pen before turning the animals out to graze. A stone was placed in a given pile for each animal that passed out of the gate. In the afternoon when the animals returned a stone was removed from the pile for each animal that entered the gate. If any stones were left in the given pile, the keeper knew that some of the flock or herd had not returned. This type of counting, no doubt is on base *one*. Pairs or two's, perhaps, is the next step in the evolution of the number system. Nature provided many birds, beasts, and insects whose appendages and other bodily structures occurred in one or more pairs. Even man himself had a pair of legs, a pair of arms, a pair of ears, and a pair of eyes. These observations evidently suggested base *two*.

Human anatomy played a prominent role in the development of the number system. The human hand contained five fingers and being conveniently located the fingers became the tool for counting and calculating. Since there were five fingers on one hand base five had its share in the formation and growth of the number system. Then the whole man with 20 fingers and toes suggested the score, or base 20.

Nearly all ancient number systems are on base 5, 10, or 20. For some unknown reason the Babylonians counted on base 60. Cantor suggests that perhaps it was done because they divided

the year into 360 days, and, therefore, the circle into 360°. They probably knew that the radius of a circle could be applied as a chord six times to its circumference. This suggested sixty as a unit of measure and hence the sexagesimal notation. The division of the day into hours and the hours into minutes, and these into seconds is due also to the Babylonians. Literature also shows that some of the ancient tribes counted on base 12. According to Cajori, the Romans were the first people to use the duodecimal system. Among the most zealous advocates of the duodecimal system was Charles XII of Sweden who at the time of his death was contemplating the change for his dominions from the decimal to the duodecimal system. This was around the early part of the eighteenth century.

To change our number system from base 10 to some other base will create too many problems. So deeply rooted is the decimal system in the life and literature of the civilized world that it is practically impossible to change it now no matter how much more convenient another system may be. Habits, customs, and traditions are much more influential than legislation; hence base 10 is here to stay. Nevertheless, there are remnants of some of these ancient number systems still in existence. The dozen, score, foot rule, yard stick, and the like are familiar terms to the average child in the elementary school. This mixture of number systems handed down for generation after generation was so inconsistent and confusing in method that the scientists agreed to adopt the metric system, for their use. The basic unit of measure in the metric system is subdivided into tenths, hundredths, and thousandths. Having a unit of measure on base 10 and a number system on base 10 make it easy to change units to lower or higher denominations. The English system which is a mixture of many ancient number systems is difficult because each column which is to be added, subtracted, multiplied or divided, is on no definite base. No doubt the reader recalls the difficulty experienced when it was necessary to perform one of the fundamental operations on denominate (or compound) numbers.

What can be done to make this mixture of number bases contained in the English system, or in any other heterogeneous system of counting, easy to the average student? The simplest answer to this question is, a thorough understanding of the common system on base 10. Teachers of arithmetic who have not thought seriously about the way the student is thinking while he is learning the fundamental operations of arithmetic

will frequently miss the point by assuming that the student knows what he is doing. This is particularly true when the student reaches the point where he must *carry* in addition and multiplication, and *borrow* in subtraction, or have *so much over* in short division.

The learner must understand how the number which is to be carried is determined. If the sum of the column which he adds is 56 say, have it well understood that we write the 6 and carry 5 because $56 \div 10 = 5$ with a remainder 6. For any column added on base 10 this statement is true. After dividing by 10, write the remainder and carry the quotient. This is also true for multiplication. Division by 10 is easily done by removing the decimal point one place to the left. The student, when shown, will soon understand that the *whole* must be carried and the *fraction* left in the column added or multiplied. To find the number to carry in any system, divide the sum of the column, or the product of one digit by another, by the base used. In subtracting one number from another, where borrowing is necessary, see that the student understands that when he borrows *one* from a column to the left, it is equal to 10 units in the column to its right. The *small one* that the student writes sometimes, in the minuend is not *one* but 10, if the base is 10; or 8 if the base is 8, and so on. In division, the "so much over" is so many tens, on base 10, or so many eights on base 8 and so on. With this concept clearly established there should be little difficulty in teaching the pupil that denominate numbers work on a similar plan. The base, so to speak, changes from column to column. For example:

Add 2 yds. 2 ft. 9 in.; 1 yd. 1 ft. 7 in., and 1 ft. 6 in.

Arrange in columns thus:

yds.	ft.	in.
2	2	9
1	1	7
	1	6
4	2	10

Explain that these columns are not on a uniform base like 10 or 8 but that 12 units in the first column equal one unit in the second and three units in the second equal to one in the third. Hence the first column (reading from right to left) is treated as a number on base 12, the second column is treated as a number on base 3. That is the sum of the first column is divided by 12.

The remainder is written under the first column and the quotient is added to the second column. This sum is divided by 3; the remainder is written in the second column and the quotient is added to the third. This is precisely what we do when we add numbers on base 10. The only difference is that there is not a uniform base for denominate numbers. The principle, nevertheless, is identical. Any other set of denominate numbers work on the same principle.

It will be an interesting and instructive innovation to introduce the method of change of base while teaching denominate numbers, or just prior to teaching them. Exercises of this sort will show just how and what is done in counting and computing on base 10, and hence just how to count and compute on any other base. The structure of the common number system will be better understood and appreciated through a study in change of base. It will mean much to show that any integer on base 10 may be written as follows:

$N_{10}=A_0X^n+A_1X^{n-1}+\cdots A_n$ where N_{10} is any number on base 10 and a_0, a_1 on to a_n are integers less than 10 and n is any positive integer including zero. For example, $2363_{10}=2(10)^3+3(10)^2+6(10)+2$. Make it clear that a number on base 10 must have ten symbols (called digits on base 10) the numerical value of the largest one, being nine (9) or one less than the base. Therefore, in general:

$N_x=a_0x^n+a_1x^{n-1}+\cdots a_n$ where N_x is a number on any base and the a's are less than x by at least one and the n's any positive integer including zero. Observe, too, that this formula teaches the importance and value of position in a number system.

To change a number from one base to another, divide the number on a given base by the base desired. For example to change $(375)_{10}$ to a number on base 6, do thus:

6)375
6)62—3 remainder
6)10—2 remainder
1—4 remainder

Write the last quotient and annex the remainders thus:

$(1423)_6$. Hence $(375)_{10}=(1423)_6$ (Read 375 base 10 equals 1423 base 6)

Now by the general formula given above, we may check the

result as follows:

$$1(6)^3+4(6)^2+2(6)+3=(375)_{10}.$$

We may also check by beginning at the left, and multiply each digit by 6 and add the next. Repeat this operation until the last digit is reached, thus:

$$\begin{array}{r} 1423 \\ 6 \\ \hline 6 \\ +4 \\ \hline 10 \\ 6 \\ \hline 60 \\ +2 \\ \hline 62 \\ 6 \\ \hline 372 \\ +3 \\ \hline 375 \end{array}$$

Observe here that the smaller the number base, the larger the number. This, for those who contend for base 8, would make numbers larger, and, therefore, more difficult to handle and would offset the advantage, if any, obtained in fractions for small numbers plus the disadvantages already mentioned in this article. Except for the disadvantages already mentioned, base 12 would be more convenient because the numbers would be smaller and at the same time have more factors.

To change fractions from one base to another use this formula to express it on base x: $F=(\cdot b_1b_2b_3\cdots)_x$ where the b's are the digits of the system to the right of the decimal point. Then $F_x=b_1+F_1$; $F_1x=b_2+F_2\cdots F_{k-1}x=b_k+F_k$ where b_k is the integral part of $F_{k-1}x$ and F_k is the fractional part of $F_{k-1}x$. Thus b_1, b_2 and so on may be found in succession. For example, express $\frac{1}{8}$ on base 6. The method with common fractions is as follows:

$$1/8\times6=0+6/8$$
$$6/8\times6=4+4/8$$
$$4/8\times6=3+0$$

The fraction, therefore, is $(.043)_6$. If $\frac{1}{8}$ is expressed decimally as

.125 we may write:

$$.125 = \frac{b_1}{6} + \frac{b_2}{6^2} + \frac{b_3}{6^3} + \cdots .$$

Multiplying both sides of the equation by 6 repeatedly first, we get:

$$0.750 = b_1 + \frac{b_2}{6} + \frac{b_3}{6^2} + \cdots ,$$

second

$$4.500 = b_2 + \frac{b_3}{6} + \cdots ,$$

and third

$$3.00 = b_3.$$

Observe that only the fractional part of the left side of the equation must be multiplied by 6. Substituting the values of b_1, b_2, and b_3 we get $(.043)_6$ again. Hence the fraction $(.125)_{10} = (.043)_6$. Notice that fractions reduced from larger to smaller bases decrease in numerical value while integers treated in a similar manner increase in numerical value. If a mixed number $(125.125)_{10}$ is given to change to base 6, it would be necessary to perform two operations. One for changing the integral part of the number and the other for changing the fractional part of it as explained above. The result is $(125.125)_{10} = (325.043)_6$. We have seen how to check for the integral part of the number. Let's see how to check for the fractional part of it: $(.125)_{10} =).043)_6$. $(.043)_6$ by the formula for a fraction is,

$$\frac{0}{6} + \frac{4}{6^2} + \frac{3}{6^3} = \frac{27}{216} = \frac{1}{8}$$

or expressed decimally $(.125)_{10}$. That is $(.043)_6 = (.125)_{10}$.

This sort of diversion gives more meaning to the principles and structure of the common number system and creates a desire for a further study of it. It makes one conscious of the manner in which counting and computing are done. Two and two are four if and only if the base of the system is five or more. To develop this type of thinking about computation gives understanding and appreciation for the growth and development of mathematics.

The motto of Marischal College, Aberdeen, Scotland, "They

say, what they say, let them say," is an appropriate statement at this point for it expresses the philosophy on which mathematics is founded. It is taken from E. T. Bell's book—*Men Of Mathematics*. To build any system of mathematics this motto must be strictly obeyed.

Change of base is met most frequently in the study of logarithms. There are only two systems of logarithms of practical importance. Logarithms to the base 10, called common logarithms and logarithms to the base e, called natural logarithms.

$$e = \lim_{n \to \infty} \left(1 + \frac{1}{n}\right)^n$$

and it has the value 2.71828 . . . . For the purpose of computation the common logarithm is the better because the mantissa is independent of the decimal point.

For scientific purposes, the natural logarithm is the most convenient. Therefore, both systems are used. However, there is a formula, based upon the intrinsic property of logarithms, to change numbers from one logarithmic base to another, given any number to a known base. For bases 10 and e, it is,

$$\text{Log}_e N = \frac{\text{Log}_{10} N}{\text{Log}_{10} e}$$

In general, the formula is

$$\text{Log}_a N = \frac{\text{Log}_b N}{\text{Log}_b a}$$

where the logarithm of the number N is known on base b.

Common logarithms of numbers are defined to be exponents of powers of 10 and hence they obey the laws of exponents. In general, a logarithm is the power of the exponent, to which a given number called the base, is raised. For example if $\text{Log}_a N = x$, $N = a^x$. The integral part of the exponent of a number is called the characteristic of the logarithm and the fractional part of it is called the mantissa.

At this point, it will be interesting to see how change of base for numbers and the corresponding change of base of the logarithms of numbers correlate. First take a very simple example. By inspection $\text{Log}_3 27 = 3$. By substituting 3 for a in the formula above—

$$\text{Log}_3 27 = \frac{\text{Log}_{10}27}{\text{Log}_{10}3} = \frac{1.43136}{0.47712} = 3,$$

which checks with the result by inspection. Now change 27 to base 3 by the rule given above:

$$\begin{array}{r} 3)\ 27 \\ 3)\ 9 \text{—} 0 \\ 3)\ 3 \text{—} 0 \\ 1 \text{—} 0 \end{array}$$

We see that $(27)_{10} = (1000)_3$. But $(3)_{10} = (10)_3$, consequently 3 checks again for the $\text{Log}_{10}1000 = 3$. Using the log formula again,

$$\log 125_6 = \frac{\text{Log}_{10}125}{\text{Log}_{10}6} = \frac{2.09691}{0.77815} = 2.69473+.$$

Since the characteristic is 2.69473+ the number on base 6 should be between 6^2 and 6^3, that is the number should be between 36 and 216, and 125 satisfies the condition. But recall that $(125)_{10} = (325)_6$. Now $(6)_{10} = (10)_6$ and since the number sought is between 6^2 and 6^3 it will correspond to a number on base 6 between 10^2 and 10^3, that is the number is between 100 and 1000. Now 325 satisfies this condition. Therefore, we see that there is no violation of definitions and principles assumed in this excursion on number bases. Rather it throws light on how to think and work with the common system more effectively. If this article makes the reader reflect on and think more critically about the way in which our number systems, and mathematics in general, grew and developed, the writer will feel that the effort was worthwhile.

BRITISH SCIENTIST LAUDS ATOMIC ENERGY REPORT

An eminent British scientist lauded the recent report of a board, set up under a Committee appointed by the Secretary of State of the United States, on the International Control of Atomic Energy. Dr. A. V. Hill, Foreign Secretary of the Royal Society of England, said:

That report is a notable example of the mixture of hard common-sense and practical idealism which is typical of America at its best. Its proposals, if adopted, might remove the nightmare of atomic warfare and so, in the end, prevent all major war; while allowing the fullest development of the beneficent effects of atomic energy by international co-operative action. The main requirement for the success of such proposals is a friendly and co-operative spirit between nations, together with good faith and a fixed determination at all costs to make the plan succeed.

NOTES FROM A MATHEMATICS CLASSROOM

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122. Sticking to the Objectives. Recently I read a news item about a science teacher who began each day's work by discussing a proverb such as "A stitch in time saves nine" or "Fortune favors the brave." It is easy to imagine how such techniques start. By chance the teacher one day meets a former pupil. He was a bright lad in the physics class, is now selling real-estate, and remembers nothing about Newton's laws. Perhaps he was a star in the chemistry class, is now a truck driver, and remembers nothing about chlorine and iodine. Or, he did good work in trigonometry, is now a welder, and has forgot what a cosine is. Each year the teacher wonders why he should teach so many things that few remember. The teacher hears more and more about habits, attitudes, the formulation of problems, symbolism, semantics, and liberal education. Finally the teacher decides that it is not worth while discussing Newton's laws, or chlorine, or cosines. Perhaps acquiring a habit of neatness and of keeping waste paper off the floor is more important than learning how to factor a^2-b^2.

This tendency to teach citizenship and manners and cultural appreciations grows as each decade brings to high school a larger and larger per cent of the high school population so that a smaller and smaller percent of them possess the intellectual curiosity that makes scholars. I have had classes in the ninth and tenth grades in which hardly four or five of the pupils would ever, either in high school or at any time afterwards, make the slightest use of anything mathematical beyond what they had already learned in the eighth grade. Like hosts of other teachers I have been confronted with the question: Shall I teach mathematics in this class or teach citizenship and maxims and morals and cleanliness? The educational experts would doubtless answer: A good teacher can do both.

I teach mathematics, not citizenship. I concentrate my efforts and time on those pupils who might, by some stretch of the imagination perhaps, make some use of factoring, of solving equations, and constructing tangents to a circle. In some classes these pupils may number only five or ten out of thirty. Of course the other twenty-five, or twenty, should not be totally neglected. I manage each period to ask each pupil at least one question so

that he will feel that he is still a member of the class. I may ask him nothing more than to erase the blackboard, but even that small chore lets him know that I am aware of his presence. I want chiefly to keep him happy so that he will not lose interest in the class and leave school too soon. Perhaps next year he may elect a more suitable course like woodworking, printing, or salesmanship. But I will not penalize the brighter pupils by limiting the instruction to the minimum essentials. I will not waste the time of the brighter pupils by doing trivial work or teaching the seventh grade arithmetic that the dull ones should have learned some years back. I aim to keep the objectives on a high level even if half of the class cannot appreciate what the other half is doing. If anyone is to suffer, let it not be the brighter pupils.

The recent report of the Harvard committee entitled *General Education in a Free Society* states (page 163): "It is probably true that any considerable softening of instruction in algebra and demonstrative geometry, to bring them within the compass of the mathematically inept, serves no useful purpose. It makes a contribution of very doubtful value to the slow students at the very real expense of the more acute."

But what shall we do with the mathematically inept? We cannot dismiss them from the class since these pupils must attend school and usually refuse to enroll in classes from which they could profit. Briefly, my answer is: Keep the dull ones happy, and the bright ones busy. I regard the dull ones as visitors who are entitled to watch the performance but are not allowed to interfere with the progress of those who are not mathematically inept.

123. The Need for more Planning. Thirty years ago the textbooks in algebra and geometry contained about three hundred pages or less; to-day, most of them have four hundred pages, and some have close to six hundred pages. Thirty years ago a teacher could begin on page one of a text and follow the pages consecutively through a text. Planning a course was unnecessary after the text had been selected. But a wealth of detailed explanations and a wealth of new material have been added. Some of this increase can be justified and makes the teacher's task easier; and some has been harmful, and makes the teacher work harder.

The poorest kind of teaching is that in which the teacher solves a problem at the blackboard and then assigns ten or

fifteen similar problems from the text. The only parts of the text that are ever used are the exercises. Thirty years ago this kind of pedagogy may well have been necessary since the explanations in the text were so brief and so pedantic that only the teacher could profit by reading them. But now the chances are good that the explanation in the text is even better than any that a teacher can give by a lecture. The teacher talks extemporaneously; the text does not. The teacher may introduce irrelevant, distracting or tangential remarks; the text has eliminated such words. The explanation in the text has been tested for clearness, has been checked in several classes, has been tested, revised, tested, and rewritten to make sure that it says what should be said and no more. The vocabulary has been checked. Hence it is better pedagogy to have the class study the explanation in the text; and part of the teacher's objective is to convince the pupil that he can learn from a printed page. The increase in the size of the text due to better explanations is fully justified, and makes the teacher's work easier.

But the five or six hundred page book, called Algebra on the title page, is more than a text on algebra. It becomes a textbook on general mathematics, shop mathematics, and grammar school arithmetic. It offers a great temptation to the teacher to teach not algebra but a host of other things. If factoring is difficult for the class, the teacher can omit it and teach areas and volumes. If algebraic fractions are difficult, the teacher has available material about statistical graphs. If the work on radicals is difficult, there are several chapters on formulas. The text has such a wealth of (elementary) material that the teacher would have no trouble with using half the text and teaching almost no algebra at all. Even if the algebraic material is not difficult for a class, the mere presence of the extra material, and its attractiveness, may divert a good class from its objective. Such texts are increasingly popular with school boards because the same text can be used in a class in algebra, in a class in general mathematics, and in a class of remedial arithmetic. And if all the classes in a school use the same text then they are all supposedly learning algebra, and there is no discrimination between bright and dull pupils; and the school board can boast that their school is truly democratic.

There is no reason why such texts cannot be satisfactory provided the teacher will plan the work carefully, is strong enough to resist the temptation to get off the road, and has the

extra time and energy for the planning. But there must be planning. At the start of the year the teacher must outline the year's work, decide what chapters to omit, what topics to emphasize, and allot a definite time for each unit. A mere selection of chapters is not enough; there must be more detail in the planning. The plan must state the exact pages to be included and how many of the exercises on each page. The teacher should keep a record of what is accomplished each week so that the plan can be revised for the next year. Further, the teacher needs a strong will so that he can resist the temptations which will beset him every day. If some day a pupil says that $\frac{1}{2}+\frac{1}{3}=\frac{2}{5}$, the teacher must not set aside his plan and spend a week teaching arithmetic. If the class is slow to grasp the solution of mixture problems, the teacher must not abandon the plan and try an easier chapter. The other chapter may indeed be easier but may not lead to the desired objectives. Often "adjusting the work to the ability of the class" is merely a cowardly surrender.

We have heard too much of the doctrine that pupils will develop an inferiority complex if they fail in their work, and hence we must assign them only tasks in which they will succeed. There can be worse things than an inferiority complex. In avoiding this complex we may give them a feeling that effort and work and perseverance are not needed to succeed. We may send them out from school thinking that life is easy and success is certain. It is true that children are spurred on to better efforts by success; at least, the tests with jig-saw puzzles given by psychologists so indicate. On the other hand, the same tests showed that adults are spurred on by failure. Evidently, the good teacher is the one who can sense when Johnny has ceased to be a child and should be treated as an adult.

When adults say that they "never could do algebra or geometry" they confess that they did not have the habit of doing today's work today, of doing their work when it should be done rather than when they felt like doing it. The pupil's success in mathematics depends on doing today's work today. In an English or a History class he may postpone work for days, but such postponements are more serious in a mathematics class. In my experience the substitution of easy topics for the more difficult ones has never converted a lazy pupil into an industrious one.

The man who has just finished unwrapping his Christmas presents is apt to agree with the proverb, "it's better to give than receive."

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solution.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the ones submitted in the best form will be used.

LATE SOLUTIONS

1985. *Hugo Brandt, Chicago*

1982. *D. F. Wallace, St. Paul, Minn.*

1987. *Proposed by Howard D. Grossman.*

Find the sum to infinity of

$$1/2+1/3+1/4-1/5-1/6-1/7+1/8+1/9+1/10-\cdots.$$

Solution by Aaron Buchman, Buffalo, N. Y.

A well known expansion into an infinite series is

$$\log 2=1-1/2+1/3-1/4+1/5-1/6+1/7-1/8+1/9-1/10+\cdots.$$

Then,

$$(2/3)(\log 2)=2/3-2/6+2/9-2/12+2/15-2/18+\cdots.$$

And,

$$(2/3)(\log 2)-\log 2$$
$$=-1+1/2+1/3+1/4-1/5-1/6-1/7+1/8+1/9+1/10-\cdots.$$

Thus,

$$1-(1/3)(\log 2)=1/2+1/3+1/4-1/5-1/6-1/7+1/8+1/9+1/10-\cdots.$$

Solutions were also offered by Hugo Brandt, Chicago and Alan Wayne, Flushing, L. I., N. Y.

1988. *Proposed by Ollie Raeder, Fayette, N. Y.*

In quadrilateral $ABCD$, if $AB=11$, $BC=13$, $CD=15$, $DA=7$ and $AC=20$, find the length BD.

Solution by C. W. Trigg, Los Angeles City College

$$\cos BAC=\frac{20^2+11^2-13^2}{2\cdot 11\cdot 20}=\frac{4}{5}, \quad \text{so} \quad \sin BAC=\frac{3}{5}.$$

$$\cos CAD=\frac{20^2+7^2-15^2}{2\cdot 20\cdot 7}=\frac{4}{5}, \quad \text{so} \quad \sin CAD=\frac{3}{5}.$$

$$\cos BAD=\frac{4}{5}\cdot\frac{4}{5}-\frac{3}{5}\cdot\frac{3}{5}=\frac{7}{25}.$$

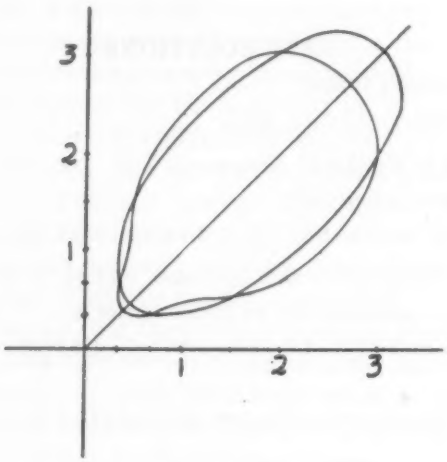
$$D=\sqrt{11^2+7^2-2\cdot 7\cdot 11\cdot\left(\frac{7}{25}\right)}=\frac{2}{5}\sqrt{793}$$

$$=11.2641023 \text{ (approx.)}$$

Solutions were also offered by A. Wayne, Flushing, L. I., N. Y.; V. C. Bailey, Delaware, O.; Hazel S. Wilson, Annapolis, Md.; Russell Hoyle, Turlock, Calif.; Aaron Buchman, Buffalo, N. Y.; Helen M. Scott, Baltimore, Md.; Abraham L. Epstein, Asbury Park, N. J.; Hugo Brandt, Chicago; Mildred Hopkins, Kankakee, Ill.; Margaret Joseph, Milwaukee, Wis.; D. F. Wallace, St. Paul, Minn.

1989. *Proposed by Walter R. Warne, Columbia, Mo.*

Solve the system:



$$\frac{(x+y+1)^2}{x^2+y^2+1}=\frac{18}{7}$$

$$\frac{(x+y+1)^3}{xy}=36.$$

Solution by V. C. Bailey, Delaware, Ohio

(1) $(x+y+1)^2=18/7(x^2+y^2+1)$

(2) $(x+y+1)^3=36xy.$

In each curve there is symmetry with respect to the line, $y=x$.
The lines,

$$y=-x+k, \tag{3}$$

will pass through corresponding points of this symmetry.
Substitute (3) in (2).

$$36x^2-36kx+k^3+3k^2+3k+1=0. \tag{4}$$

Substitute (3) in (1)

$$36x^2-36kx+11k^2-14k+11=0. \tag{5}$$

The constant terms of (4) and (5) are equal.

$$k^3+3k^2+3k+1==11k^2-14k+11 \tag{6}$$

$$k = 1, 2, \text{and } 5. \tag{7}$$

If these values of k are substituted in (4) and (5), the following values of x result:

$$x=1/3, 1/2, 2/3, 3/2, 2, 3. \tag{8}$$

The corresponding values of y may be found by using (3).
Associating the values, we have the following real solutions:

$$x=1/3, 1/2, 2/3, 3/2, 2, 3$$
$$y=2/3, 3/2, 1/3, 1/2, 3, 2.$$

(Note on Figure. A branch of curve (2), not shown, lies in quadrants three and four.)

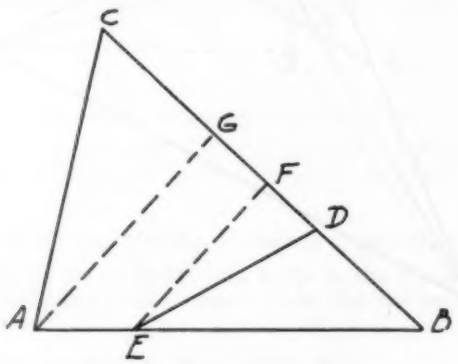
Solutions were also offered by Hugo Brandt, Chicago; Philip Rosenblatt, Brooklyn, N. Y.; Charles W. Trigg, Los Angeles City College; Orville F. Barcus, Philadelphia, Pa.; Alan Wayne Flushing, L. I., N. Y.; Helen M. Scott, Baltimore, Md.; Hazel S. Wilson, Annapolis, Md.; Russell Hoyle, Turlock, Calif.

1990. *Proposed by Gladys Platner, Oneonta, N. Y.*

In triangle ABC, if D is located on BC, so that $BD=\frac{1}{3}BC$, and if E is on AB so that $BE=\frac{3}{4}BA$, what part of triangle ABC is BED?

Solution by Helen M. Scott, Baltimore, Md.

Draw EF and $AG\perp BC$. Triangles EBF and ABG are similar. Since



$$BE=3/4BA, \qquad EF=3/4AG.$$

$$\text{Area of } ABC=\frac{AG\cdot BC}{2}.$$

$$\text{Area of } BED=\frac{EF\cdot BD}{2}.$$

$$\text{Area of } BED=\frac{3/4AG\cdot 1/3BC}{2}$$

$$=1/4\left(\frac{AG\cdot BC}{2}\right)$$

$$\therefore \quad BED=1/4ABC.$$

Solutions were also offered by Mildred Hopkins, Kankakee, Ill.; Alan Wayne, Flushing, L. I., N. Y.; Abraham L. Epstein, Asbury Park, N. J.; Margaret Joseph, Milwaukee, Wis.; Aaron Buchman, Buffalo, N. Y.; D. F. Wallace, St. Paul, Minn.; Charles W. Trigg, Los Angeles City College; V. C. Bailey, Delaware, Ohio; Hazel S. Wilson, Annapolis, Md.; Russell Hoyle, Turlock, Calif.

1991. *Proposed by Hugo Brandt, Chicago, Ill.*

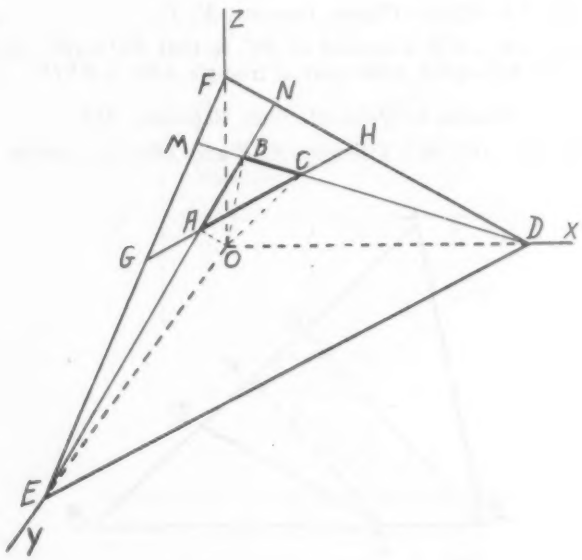
Find the volume of the solid enclosed by the planes $z=2x$, $z=3y$, $3x+3y=4.5z$, and $6x+6y+11z=120$.

Solution by V. C. Bailey, Delaware, Ohio

In the figure the plane, $z=2x$, is shown by the triangle EON; $z=3y$ by triangle DOM; $3x+3y=4.5z$ by triangle GOH; $6x+6y+11z=120$ by triangle DEF.

The solid bounded by the four planes is the tetrahedron O–ABC.

The coordinates of its vertices are



$$A: \quad x=3, \quad y=6, \quad z=6$$
$$B: \quad x=3\tfrac{3}{4}, \quad y=2\tfrac{1}{2}, \quad z=7\tfrac{1}{2}$$
$$C: \quad x=7, \quad y=2, \quad z=6$$
$$O: \quad x=0, \quad y=0, \quad z=0$$

$$\text{Volume}=1/6\begin{vmatrix} 0 & 0 & 0 & 1 \\ 3 & 6 & 6 & 1 \\ 7 & 2 & 6 & 1 \\ 3\frac{3}{4} & 2\frac{1}{2} & 7\frac{1}{2} & 1 \end{vmatrix}=20.$$

Solutions were also offered by Alan Wayne, Flushing, L. I., N. Y.; Aaron Buchman, Buffalo, N. Y.; C. W. Trigg, Los Angeles City College; Hugo Brandt, Chicago

1992. *No complete solution has been offered.*

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

Editor's Note: For a time each high school contributor will receive a copy of the magazine in which the student's name appears.

For this issue the Honor Roll appears below.

1990. *R. W. Gouinlock, Upper Canada College.*

1989. *N. K. Macklem, Upper Canada College.*

PROBLEMS FOR SOLUTION

2005. *Proposed by Luella Bochnein, New York City.*

Solve for x: $\sqrt{x-1}+\sqrt[3]{x}=\sqrt[5]{x+1}$.

2006. *Proposed by Grace Marsh, Mexico City, D. F.*

In any plane triangle ABC, if $\tan A=2\tan B$, show that $3a^2=3b^2+c^2$.

2007. *Proposed by Hugo Brandt, Chicago.*

The limit of the regulation size of an overseas package is 42" for "length plus girth." Compute the maximum contents of such a package if its shape is

a) box like,

b) cylindrical.

2008. *Proposed by Howard D. Grossman, New York City.*

In triangle ABC, $B=C=80°$. Select D on AB and E on AC so that $\angle CBE=50°$ and $\angle BCD=60°$. Prove by plane geometry that $\angle CDE=30°$.

2009. *Proposed by Norman Anning, University of Michigan.*

A stone falls freely from the top of a house to the ground. It falls the last nth of the height in $1/n$ of a second. Show that the house is not more than 65 feet high.

2010. *Proposed by Isadore Gosz, West DePere, Wis.*

Three consecutive chords of a circle whose lengths are 1, 2, and 3, respectively, subtend a semicircle. Find the diameter of the circle.

BOOK REVIEWS

ALL AROUND US, BOOK B; and HOW DO WE KNOW, BOOK C. Basic Studies in Science; Curriculum Foundation Series, Teachers Edition by Wilbur L. Beauchamp, Gertrude Crampton and William S. Gray. Book B. pp. 134, 1944; $1.08, Book C. pp. 179; $1.24; 1945. Scott, Foresman and Company, Chicago.

The two books *All Around Us* and *How Do We Know* are the second and third books respectively in a series of pictured lessons in science for children of the primary grades. These books have been so constructed that the child is led from the development of science concepts of the environment through relationships concerning this environment to generalizations within the comprehension of pupils of his grade level. Because the lack of ability to read often interferes with the pupil's understanding of the ordinary science textbook, the authors present their material in picture form. Book B has only a few printed words, phrases and sentences.

Book C relies upon the child's growing comprehension of the printed word and introduces much more of a verbal text. This book forms a transition from the picture-story to the printed story and gives directions, questions and labels to be read. The vocabulary and sentence structure are simple. According to the authors, 470 different words are used; they also state that only slightly under 200 should be new to children in the last half of the second year. Of the new words, the authors tell us "101 are labels used to develop identification techniques, and are, therefore, readily established through functional use." Areas of interest in this book are animals, land and water, forms, plants, wheels and levers.

The Teacher's Edition of Books B and C is composed of two main parts; the first, the teacher's "Guidebook"; the second, the section for the children's use. The "Guidebook" is well done and offers many valuable suggestions to the teacher who is inexperienced in the use of the pictured-textbook with children. It explains the purpose of the types of pages used in the pictured-text such as that found in Book C, namely the Unit-Picture, Story Picture, Generalizing, Pictured-Experiment, Diagram and Application. It gives specific directions for the use of the book in the teaching of each unit. General concepts and detailed lesson plans are worked out. Both books have good bibliographies, Book C having a word list and appendix in addition.

A skillful teacher should find these books of interest. The pictures are colorful and should appeal to children. In some instances the large number of pictures on one page may result in confusion. Also it would seem that the child might develop the wrong concept of size relationship when studying the few pages such as 15 of Book B where a young chick appears nearly as large as the young goat in the picture next to it.

The Guidebook calls attention to the actual size of many of the animals but it seems that the relationship should be brought out more clearly in a few instances, especially where pictures are close together or the child might be unfamiliar with the animal itself.

D. V. PHIPPS
Chicago Teachers College

BRAZIL ORCHID OF THE TROPICS, by Milford and Racine Foster. Cloth.

Pages 314. 137 photographs. 4 Kodachromes. 32 Sketches, 6½×9½ cm Index. 1945. Science Press, Lancaster, Penn.

A descriptive narrative of a bromeliad collecting tour along the jungle coast of Brazil. The greatest interest of the collectors was in the "pine-apple-looking" members of the bromeliads that grow as epiphytes or "air" plants. They discovered and brought back many new specimens. Their interesting descriptions of the Brazilian jungle include many of the forest products such as palms, rubber, mandioca and others. The cacao is shown to be important food for many natives at Aqua Preta. Farther south in Parana, mate, the leaf of the holly, is made into tea that is free from acid. It is the most common drink and is drawn through a silver tube from a gourd. The volume provides geographical glimpses that are new and original.

VILLA B. SMITH

ROCKS AND RIVERS OF AMERICA, by Ellis W. Shuler, Professor of Geology and Dean of the Graduate School of Southern Methodist University in Dallas, Texas. Illustrated. Cloth. Pages xx+300. 24×16 cm. 1945. The Jaques Cattell Press, Lancaster, Penn. Price $4.00.

This volume interprets the landscape in terms of its geology and the changes wrought by such forces as wind, water, ice and vulcanism. The presentation is clear and direct. Its explanatory style is delightful. The areas interpreted are many and varied. The 105 photographs which illustrate the volume are excellent and well chosen. The descriptive information accompanying them adds greatly to their value. This is a volume that will appeal to the student of physiography and to the layman as well.

VILLA B. SMITH

CAREERS IN SCIENCE, by Philip Pollack in Collaboration with Vocational Guidance Research, Evelyn Steele, Director. Cloth. 222 pages, 13.5 ×20.5 cm. 1945. E. P. Dutton and Company, Inc., 300 Fourth Avenue, New York, N. Y. Price $2.75.

Science is now one of the most popular of school subjects of study and also of post war jobs. From the record of registrations in college courses the sciences are now leading the field. In nearly every college teachers of mathematics, physics and chemistry are needed. It is evident that many returning soldiers, sailor, and airmen, now registered in these classes, will not be satisfied with their progress nor with the returns when the courses are completed. This book is designed to give these students a look into the future. Jobs are discussed—the nature of the work, preparation required, living conditions, and the salaries or wages paid. Chemistry, physics, biology, geology are each given special treatment. By reading the student may learn what preparation he must make, the amount of mathematics, drawing, English, public speaking, etc. he must master, if he is to succeed. Following the discussion of each major career is a view of the salary to be expected and the time it will probably take to reach the maximum. Unlike many books of the past this one does not paint an easy, highly remunerative picture of the engineer or scientist at work but attempts to give young men and women an actual view of what is before them if they succeed. A chapter is devoted to the work of women in science. The last two sections, one by Dr. Albert W. Hull and the other by Charles F. Kettering, are of especial interest. Here students listen to men who have this problem to deal with all the time and have successfully met many of its perplexities.

G. W. W.

THE FIRST HUNDRED YEARS OF THE SMITHSONIAN INSTITUTION, 1846–1946, by Webster P. True, Chief of the Editorial Division of the Institution. Paper. Pages viii+64+39. 17×25.5 cm. 1946. Washington, D. C.

A comparatively small number of the people of this country know much of the Smithsonian Institution. How an Englishman bequeathed his entire estate to the United States, then a young nation he had never seen, how the bequest was debated in Congress before it was finally accepted, how the Institution was finally launched, how it has grown, and its great influence on the development of all branches of science form an interesting series of topics everyone should know. A few brief chapters tell just a little about this great treasure house of the nation. A few pages on the American Indian, both the prehistoric Folsom man and the Indian of today, give an idea of one field of study. The Astrophysical Observatory and its great branches make up another chapter. The live animals of the National Zoological Park, how they are collected and how they live in a beautiful Rock Creek valley are discussed in Chapter VI. Then follow a few pages on the various great exploring expeditions. The wonderful gallery of art, that has just had its beginnings in recent years but is now rapidly becoming a great art center. Finally a few pages are given to the publications of the Institution and the International Exchange Service, then a brief statement of the wartime service of the Institution.

After looking over this brief description one wishes that more had been told and that the binding had been made more permanent. The thirty-nine pages of beautiful illustrations deserve much more than a place in a book with only paper covers.

G. W. W.

THE QUIZ SECTION

JULIUS SUMNER MILLER

Chapman College, Los Angeles, California

1. The onion is biennial and the dandelion is perennial. (T or F)
2. What are maggots?
3. A mushroom is a fungus (T or F)
4. If a decimal terminates it represents a rational number. (T or F)
5. It has been proved that EVERY map *can be* colored with 5 colors. (T or F)
6. Between EVERY pair of rational numbers, *no matter how close together*, there is an irrational one. (T or F)
7. Cement and concrete are synonymous terms. (T or F)
8. We put food in the refrigerator to retard its decay. This is a good example of the change of reaction rate with temperature. (T or F)
9. Shaking two *immiscible* liquids together forms an emulsion. (T or F)
10. Hurricanes and typhoons are names for the same type of storm. (T or F)
11. What is the technical name (geological) of the "Great Ice Age"?
12. It is IMPOSSIBLE to find two even numbers whose sum is odd. (T or F)
13. Cobra venom is used in minute doses to relieve pain in operations. (T or F)

ANSWERS TO THE QUIZ SECTION

1. T; 2. The legless larvae of flies; 3. T; 4. T; 5. T; 6. T; 7. F; 8. T; 9. T; 10. T; 11. The Pleistocene Epoch; 12. T; 13. T.

THE ICAROSCOPE

The lid was lifted October 3 on one of the United States Navy's most important air defense secrets, the Icaroscope, a device which enabled pilots to spot an enemy airplane speeding toward them directly in line with the sun.

Dr. Brian O'Brien, professor of optics and physics at the University of Rochester, described the telescope-like device to more than 700 fellow-members of the Optical Society of America at the opening session of the Society's thirty-first annual meeting at the Pennsylvania Hotel.

The Icaroscope, named after the Greek mythological Icarus who flew so close to the sun that the wax which held his wings melted and caused him to fall into the sea, takes advantage of what is known as afterglow in a phosphor screen. Phosphor is the term applied to a substance which stores up energy when excited by radiation of short wave lengths or high energy particles. In the Icaroscope as used by Navy pilots it soaked up sunlight.

The image, such as an enemy plane in bright sunlight, is formed on a transparent phosphor screen while the screen is hidden from the eye. A double rotating shutter then closes off outside light and the pilot sees the image 1/100 second later. By this time the brilliance of the sunlight on the phosphor screen is only 20 to 50 times that of the surrounding sky as compared with the sun's real brightness which is 10,000 to 100,000 times that of the surrounding sky. The result is that a plane can be seen on the screen silhouetted against either the sun's disk or the surrounding sky.

The disks are rotated by an electric motor at about 100 cycles per second so that the viewing appears to be continuous as in a high speed motion picture camera. The Icaroscope looks like a short, stubby telescope.

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WEED-KILLING DUST BOOSTS WHEAT YIELD IN BRITAIN

Methoxone, a weed-killing chemical related to the 2,4-D now being used in the United States, has shown itself able to increase the per-acre yield of wheat, in extensive field tests carried on in Britain during the past three years. Mobile dusting units have applied the compound to not less than 13,000 acres, which have returned harvests stated to average 22% greater than those from untreated fields.

It is known here that similar experiments with 2,4-D have been conducted on grain fields in Canada and the United States; but the more extensive tests in Britain have been spurred by the necessity for obtaining maximum food returns from this country's much smaller producing area.

CANADIAN SCIENTIST REPORTS ON RESEARCH

In spite of medical advances, the life expectancy of a person at age 50 today is practically the same as it was 20 years ago, yet there is no chemical, physical or physiological reason why the average adult should not live 110 or 115 years at least, Dr. I. M. Rabinowitch, Director of the Department of Metabolism and Toxicology at the Montreal General Hospital, told a gathering of Canadian scientists and educators.

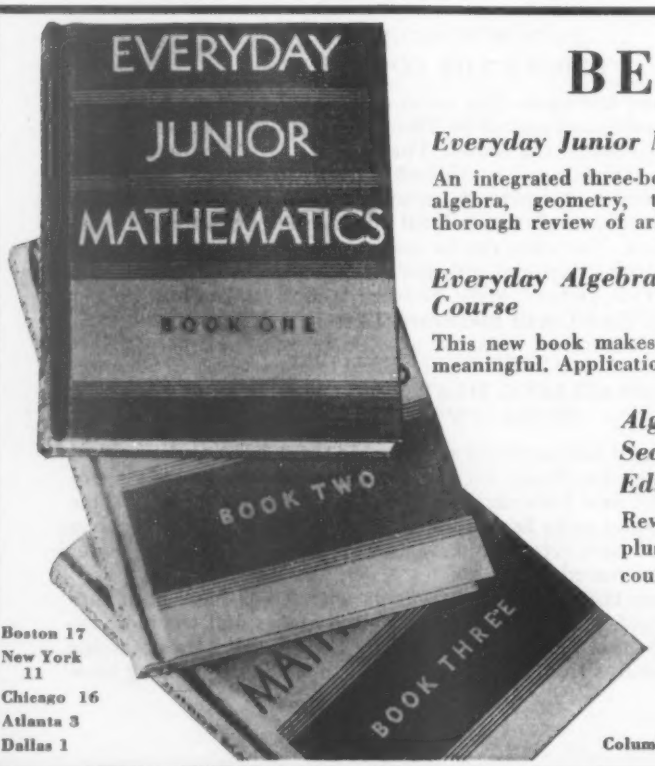
"We know that many of man's organs are designed to function twice as long as the average span of life according to present day standards, but before that goal can be achieved we must have a better knowledge of nutrition," Dr. Rabinowitch said.

He pointed out that enormous strides have been made in the field of nutrition in the past twenty-five years. He declared, however, that "specialists in nutrition realize they are just on the threshold of knowing how to use foods for greatest benefit.

"Even bringing diets up to what are presently considered optimum levels would undoubtedly lengthen the life of a great majority of the population, but when research discovers more about the influence of one type of food on another, science will add years to man's life and make those years more productive," he said.

By way of illustrating the practical value of research, Dr. Rabinowitch said that studies in the nutritional value of different sugars have revealed that common table sugar has unique properties. Instead of merely breaking down in the body, during ingestion, into two simple sugars—dextrose and levulose—he reported that another compound is formed which has an influence on metabolism and thus, on nutrition.

"Studies have shown that common sugar is more readily available as fuel than the mixture of the two simple sugars. This is of particular importance since Carbohydrates account for over one half the food in normal diet and are more useful for manual work than fats and proteins," he stated.



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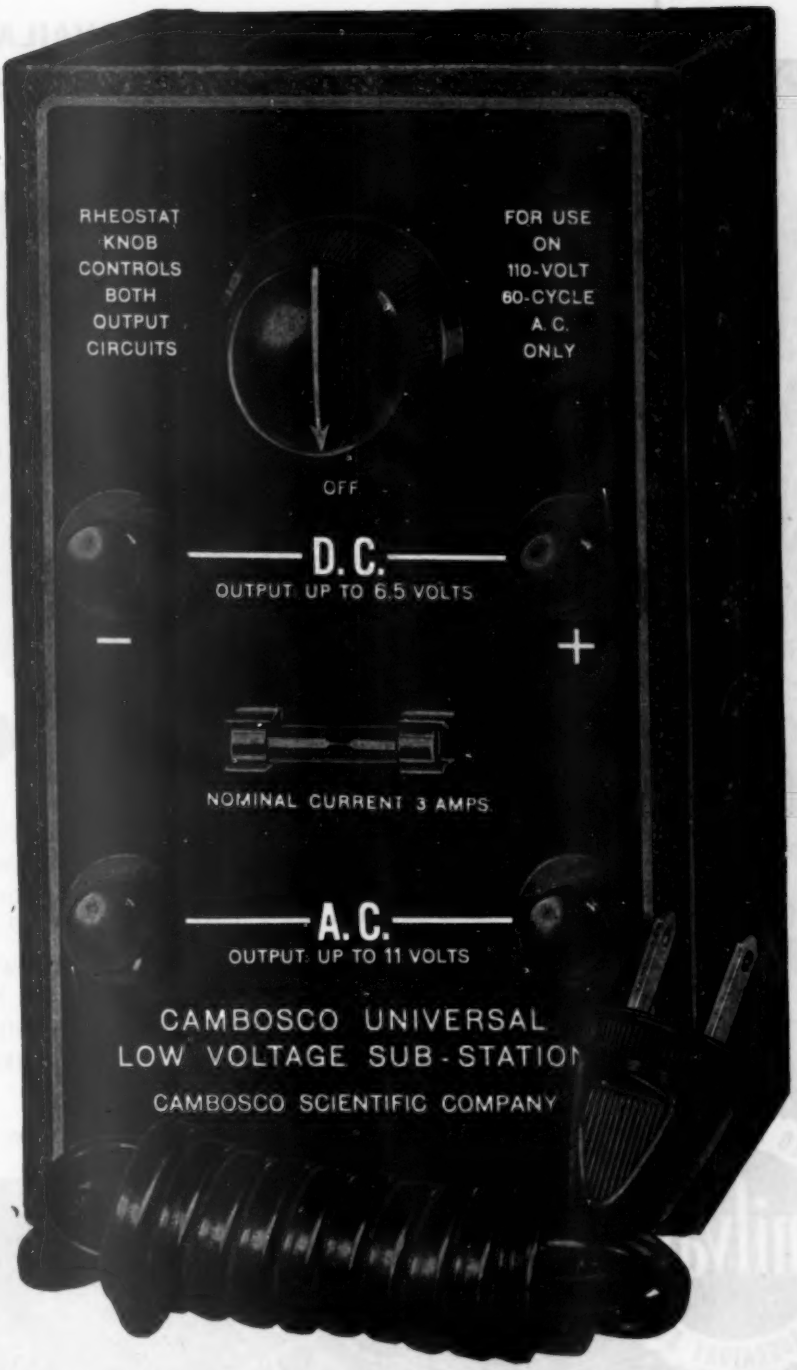

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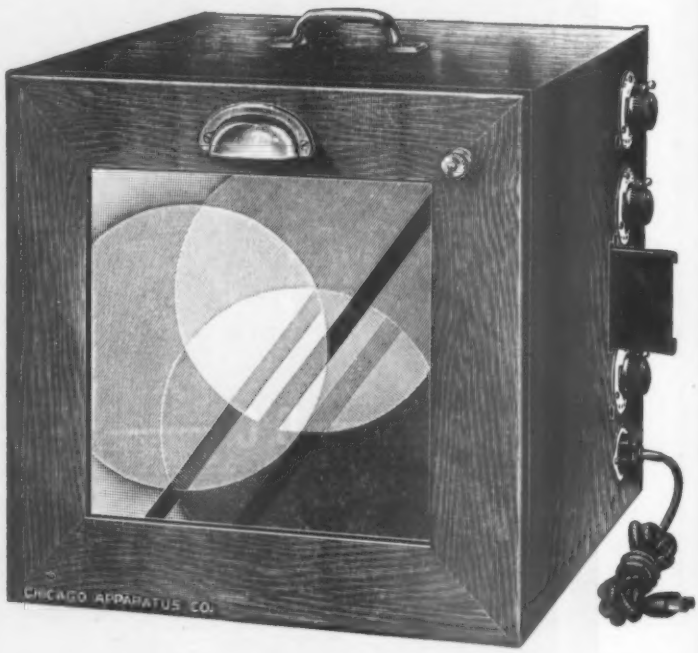

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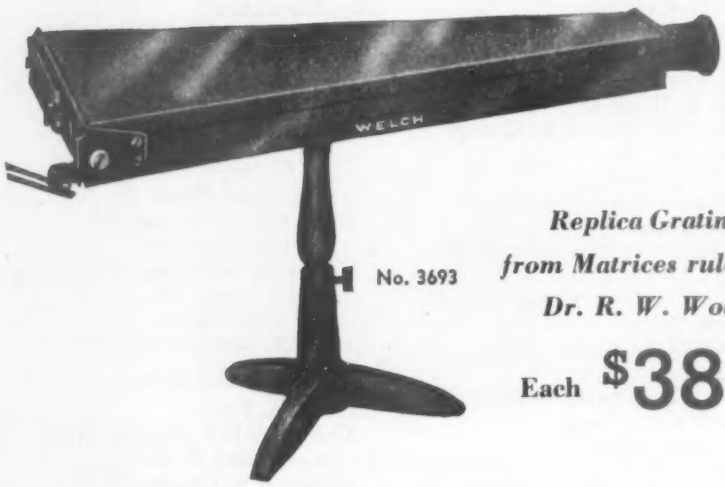

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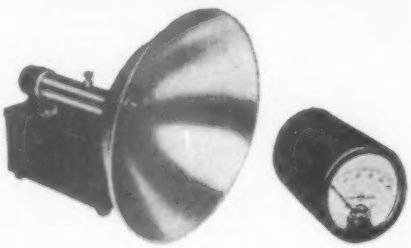

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